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A TRIP IN THE ZEPPELIN AIRSHIP.

EMIL SANDT, in the Illustrirte Zeitung, gives the following picturesque account of a flight in Count von Zeppelin's gigantic airship:

"Early in the morning Prof. Hergesell, Freiherr von Bassus, Dr. Stalberg, Herr Uhland, and myself set out in Count Zeppelin's launch for the shed in which the great airship is housed. When we arrived everything was in readiness for us. Count Zeppelin is proud of the fact that his colossal craft can be drawn in and out of the shed with very little help. In seven minutes the huge gas bag had emerged, and a few minutes later we were floating up into the sky. I took my station in the central car or cabin, a comfortable room flooded with the yellow light that filters through the translucent balloon fabric of which the walls, the floor, and the ceiling are constituted. Comfortable seats suspended from fine chains provide a seating capacity for a dozen passengers.

"For a greater portion of their length the walls are provided with celluloid panes. The floor is also transparent wherever it is not used as a footway. Seated comfortably in the central car, I could look down through my knees and see the green earth, water, people, cities, and castles far below. I could also see birds circling around and fluttering anxiously, evidently frightened by the strange giant of the air.

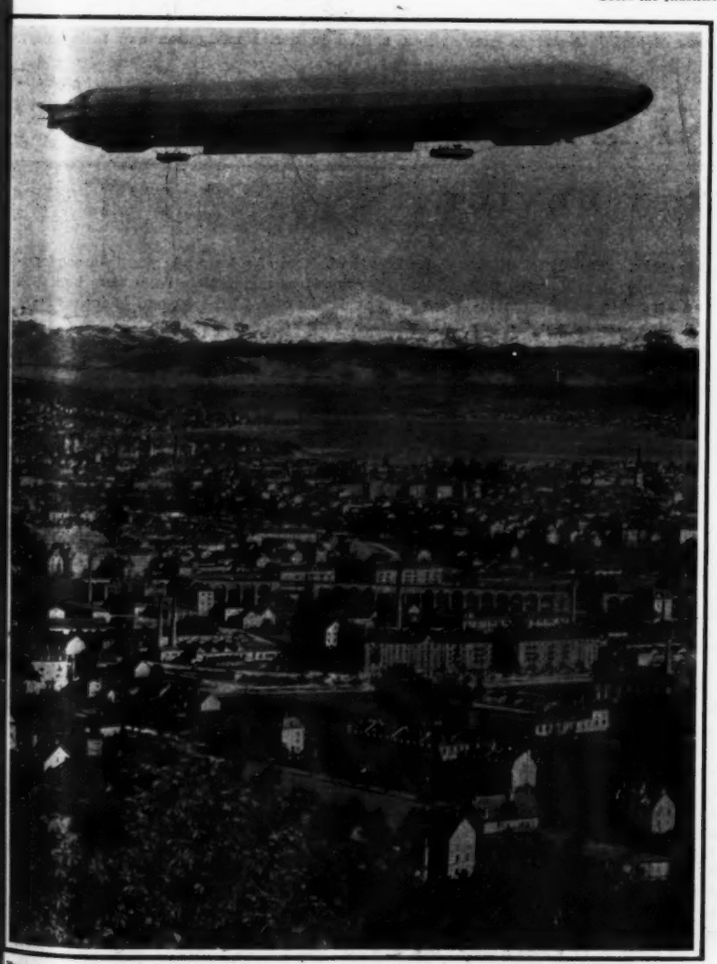
"We crossed over to the Ueberlinger See, traversed the intermediate neck of land, and turned into the valley of the Rhine at Konstanz. Here I left the central car and walked toward the rear car along the keelway, which is flanked with balloon cloth, and which is

WIMPFEN. ELEVATION, 6,560 FEET.

ROTHENBURG. ELEVATION, 7,500 FEET.

THE TAENNCHEL. ELEVATION 2,600 FEET.

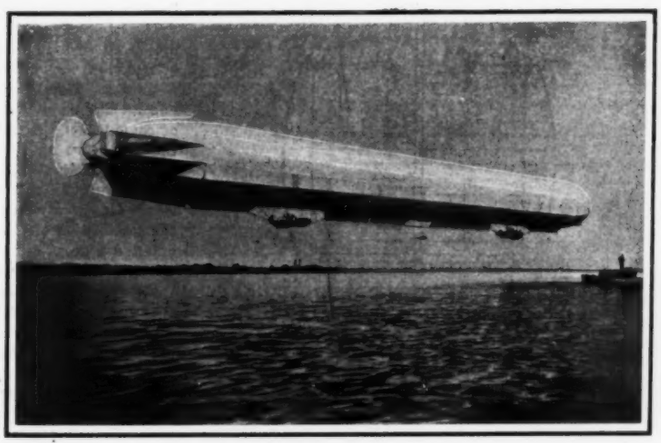
From the Illustrirte Zeitung.



From the Sphere.

THE ZEPPELIN AIRSHIP HOVERING ABOVE THE TOWN OF ZÜRICH.

THE KING OF WUERTTEMBERG (X) AND COUNT VON ZEPPELIN IN THE CAR.



THE AIRSHIP IN FLIGHT WITH THE QUEEN OF WUERTTEMBERG ON BOARD.

A TRIP IN THE ZEPPELIN AIRSHIP.

closed at the end of the keelway by a celluloid door. I opened the door and stepped out on the narrow aluminium gangway, which runs down sharply to the rear car. The gangway has no protecting handrail. It is merely ribbed to give a better foothold. That apparently flimsy structure bridges a chasm of twenty feet between the end of the keelway and the car. From below, the passage from the keelway to the car must seem perilous indeed, but up in the airship itself no fear is felt. I stood on this narrow bridge and gazed at the landscape. To the north I could see the Hohendtwiel. Behind us lay the Swabian See glistening in the morning's sun. In the southeast I saw Thurgau wrapped in violet light. On the horizon the lofty peak of the Saentis rose broad and jagged, capped with ice and snow. Below us writhed the Rhine. I looked across at the propellers. Count von Zeppelin had signaled full speed ahead. The giant airship trembled. The propellers seemed like disks, revolving with furious speed and yet as transparent as a locust's wings. They gave out a note like that of a deep organ, so loud that the human voice, even when lifted to a shriek, could hardly be heard.

"I walked down to the rear car to obtain a better view. Here the gigantic craft could be seen in a wonderful perspective. The sensation was strange. The giant ship obediently sank and rose. Obediently moved to the right or to the left, slavishly following the slightest pressure of the human hand. Sometimes its angle was such that the entire fabric seemed inclined like a kite. At times the forward car lay below us; at times we had to look up at it.

"As we neared the splendid falls of the Rhine at Schaffhausen, the Count brought the airship down, in order to ascertain whether the eddies occasioned by the waterfall would have any effect.

"We turned into the Reusstal, but were buffeted by the wind all the way up the valley. To the south the sharp jutting peak of Mt. Pilatus hove in sight. Soon Lucerne appeared, a jewel among cities. The lake itself shimmered brightly where it was struck by the sun; its darker portions lay like an emerald, held in a setting of heliotrope. It was like a melody in colors. Below us in Lucerne itself there was a hubbub and a great jubilation. The streets were crowded with gayly-clad people. The roofs were a-swarm. Zeppelin guided his airship down, and allowed it to glide full speed over the city at the height of the church steeples.

"We traveled over the Vierwaldstaetter See, and crossed to Kuessnacht, to Zug Lake, and up northward to Zug itself. Then came the most difficult task which Prof. Hergesell had assigned to the airship. The craft was to carry us straight across to Lake Zürich, through a narrow pass where it would be caught in a veritable cyclone. The motors groaned and rattled. The propellers howled a deep droning song. The airship did all that it could. The wind was dead against us, traveling with a velocity of nearly 31 miles an hour. The Count could easily have arisen and escaped the fury of the blast, but it was his purpose not to avoid obstacles, but to court them. Whenever the great airship showed signs of swerving, it was brought back into its course. Far below us in the valley the sharply-marked shadow of the airship, crawling slowly from tree to tree, showed us how hard it was struggling. There were minutes when it seemed as if we stood stock still despite the infernal music of the propellers. Gradually the nose of the craft was thrust forward; once more the airship mastered the wind. We had forced our way through the pass, and were dashing on at full speed. The vast shadow below us traveled with the velocity of a bird over mountains, valleys, cliffs, and rocky points, over railway embankments and roads, over water and land."

Since the foregoing account was written, Count von Zeppelin's airship while undergoing a 24-hour test was completely destroyed. How the catastrophe occurred is not clear. Full details have not as yet been received. The airship had been compelled to descend in the open country near Echterdingen, partly because of excessive loss of gas, partly because of engine trouble. The landing seems to have been made safely enough. During a severe thunderstorm which prevailed at the time, the huge gas envelope was blown about by the high wind, and thrown on one side, with the result that one of the sixteen gas compartments burst open. The escaping hydrogen was ignited in some inexplicable way, and the blazing structure was wafted up by the wind. The large quantity of gasoline and lubricating oil which the Count had carried along for the 24-hour run was not ignited, curiously enough. Four of Count Zeppelin's mechanics were injured.

On the first of July last the airship successfully accomplished a twelve-hour flight at an elevation which varied from 1,000 to 2,500 feet. The distance covered was 220 miles; the average speed was 30 miles an hour. It was this brilliant performance that induced the Count to undertake the 24-hour flight which the government had made a condition precedent to its acceptance of the craft and which has ended so disastrously.

Following the principle which he had laid down nearly ten years ago in the construction of his first airship, the craft was built around a rigid aluminium frame, which assumed the form of a cylinder about 450 feet long, and which was divided into sixteen gas compartments, similar to the water-tight compartments of a steamship. The gas envelope which was stretched over the frame consisted of alternate layers of canvas and rubber. About 7,500 square meters (80,730 square feet) of fabric were required. Had silk been used, as in the French military airship "Republique," about 800 pounds dead weight would have been saved. Silk, however, cannot be gummed, but must be varnished, which is the chief reason why the Count decided not to use it. Because of this rigid structure, the gas envelope always retained its shape no matter how much or how little it contained. On the other hand it has always been objected that on account of its rigidity the airship could not alight on land without sustaining severe shocks which would inevitably cause damage. To overcome this objection Count Zeppelin intended to use air cushions which would break the shock. Whether or not these air cushions were used on the last ill-fated journey the airship seemed to have alighted easily at Echterdingen.

The airship was driven by two 110 H.P. Daimler motors, one in each car. Each motor weighed 1,1[illegible] pounds, and was therefore heavier than aeronautic motors are apt to be. On the other hand the motors were economical in fuel consumption and in lubricating oil. Considering the large amount of gasoline and oil required for a long flight, the weight of the heavy economical Daimler was about equal to that of the light but uneconomical aeronautic motor of equal horse-power. Reversing gears were provided in order to drive the propellers astern and to stop the airship quickly when occasion demanded. The propellers in question were carried on the lower side of the gas envelope. They were comparatively small, for Count Zeppelin had discovered that it was advisable to drive them at about the same speed as the motor-shaft.

A simple and ingenious steering gear gave the Count the fullest control of his huge craft. To guide the airship up or down four superposed planes were secured to the gas envelope near its forward end. Besides serving as rudders the planes added to the stability of the airship. At a speed of 45 feet a second the planes exerted a lifting effort of 1,760 pounds, sufficient to keep the craft afloat even if there was considerable leakage of gas.

With a gas capacity of 15,090 cubic meters (532,88[illegible] cubic feet) the airship could lift 16,800 kilos (37,03[illegible] pounds). Since the airship itself weighed 12,000 kilos (26,455 pounds), it could carry 4,800 kilos (10,58[illegible] pounds) in the way of freight, passengers, etc. The crew consisted of twelve men, two of whom were pilots, skilled in aerial navigation and meteorology.

THE STORAGE OF INFLAMMABLE LIQUIDS.

A NEW SAFETY DEVICE.

Martini and Huenecke have invented and patented a system of storing and distributing gasoline and other inflammable liquids which reduces the danger of explosion to a minimum. Explosions are caused either by the ignition of mixtures of inflammable vapors with air or by the simple expansion of the vapors, by heat, without ignition. In the new system the formation of an explosive mixture is prevented by filling the void above the liquid in the reservoir with carbon dioxide or some other inert gas, under a pressure sufficient to force the liquid through safety distributing pipes ending in self-closing cocks. The distributing pipes are double. The inner pipe starts from the bottom of the reservoir and serves to convey the inflammable liquid. The outer pipe starts from the top of the reservoir and is consequently filled with the compressed inert gas. Hence if the outer pipe is broken by accident the gas escapes from the reservoir and outer pipes, and the liquid immediately flows back from the inner pipes to the reservoir, which, for security against fire, is placed underground. This arrangement not only prevents explosion in conflagrations but gives evidence of the slightest leak in the outer pipes by cutting off the flow of the liquid through the inner pipes and cocks.

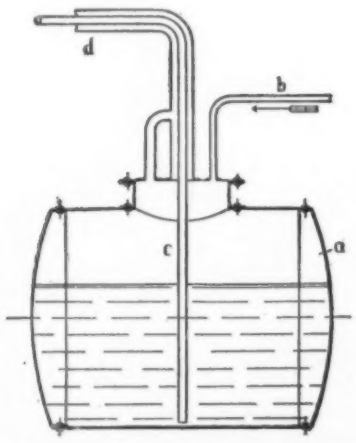


Fig. 1.—STORAGE AND DISTRIBUTING SYSTEM FOR INFLAMMABLE LIQUIDS.

a. Underground reservoir. *b*. Gas supply pipe. *c*. Inner pipe for liquids. *d*. Outer pipe filled with compressed air.

The system proved its efficiency at a fire which broke out in a small garage in Hanover while a cask of gasoline was being emptied into the underground reservoir. The building was only slightly damaged and an automobile which stood in it was not put out of commission. A far more severe test was passed at the great fire in the Victoria warehouses in Berlin, where more than 30,000 gallons of gasoline, stored in an underground reservoir, lay under a pile of burning ruins for twenty-four hours. The explosion or even the combustion of this quantity of gasoline would have entailed a great direct loss and would also have given the conflagration a vastly more serious character.

Notwithstanding this satisfactory result, it was this very fire that led the Hanover fire department to make a series of experiments for the purpose of determining the penetration of the soil by the heat of a fire above it. Three broad piles, about three feet high and three feet square, with slopes of 45 degrees, were constructed of dry sand, nearly dry clay, and wet rubbish. On each pile was erected a brick furnace, in which a hot fire of coke was maintained, so that the upper surface of the piles inside the furnaces acquired a temperature of about 2,200 deg. F., which is seldom or never attained by the bottom of a heap of ruins in a conflagration. Thermometers and fusible balls were buried in the piles at depths of 4, 12, 20, 30, and 40 inches below the surface, and were examined hourly.

It was found that even very thin layers of earth have a great power of thermal insulation. In the pile of rubbish, for example, after the fire on top had been burning 21 hours, the temperatures in Fahrenheit degrees were, 518 at the depth of 4 inches, 185 at 12 inches, 122 at 20 inches, 68 at 30 inches, and 62½ at 40 inches. Moisture was found to retard the penetration of heat very greatly. In the wet pile, at the small depth of 4 inches, the temperature remained at 212 deg. F. (the boiling point of water) until the moisture had been almost entirely evaporated.

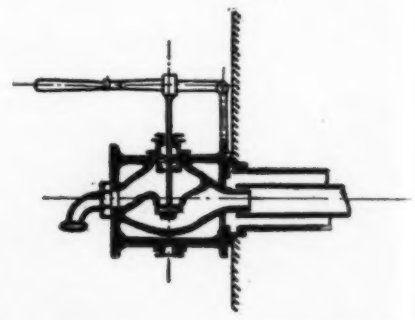


Fig. 2.—SAFETY COCK WHICH RETAINS THE LIQUID WHEN BROKEN.

At the depth of 20 inches, 46 hours of firing were required to raise the temperature to 158 deg. F., the aver

age boiling point of commercial gasoline, and at 40 inches below the surface only a very small rise of temperature was produced by 70 hours of brisk firing.

Hence it appears quite sufficient to put the highest part of the gasoline reservoir 20 inches below the surface of the ground for, apart from the improbability that a surface temperature of 2,200 deg. F. will be maintained during 46 hours as the result of a conflagration, gasoline could not be caused to boil by a temperature of 160 or 170 deg. F., produced by a fire above, because of the cooling of the reservoir by the colder strata of earth below.—Umschau.

GASOLINE, GAS, STEAM, AND ELECTRICITY.*

THEIR COMPARATIVE COST FOR SMALL POWERS.

BY WILLIAM O. WEBBER.

THE comparative cost of the various sources of power is a matter of very great interest in installations of small power where any one is equally available and the sole determining factor is expense. In the usual determination of these relative costs it has been assumed that the total cost of a new plant was merely the cost of the machine plus the cost of the material required to run it, and that the additional cost of depreciation, interest, insurance, etc., would be the same in each instance. It is also generally assumed that the power costs just so much per horse-power regardless of the amount used. These are both very erroneous impressions.

The following tables give the itemized cost of 1 horse-power per hour on 2, 6, 10, and 20-horse-power plants, respectively, for gasoline, gas, steam, and electric power.

Table I shows the cost of gasoline power, and is based on fact, not theory. All gasoline engines do not run on one-eighth of a gallon of gasoline per brake horse-power per hour, and to get at fair comparative results, proper allowances must be made for depreciation, repairs, and insurance, as well as taxes, and the room occupied by the plant must be taken into account.

Table II shows the costs for the same powers driven by electricity. It will be noted that proper allowance must be made for attendance, although this item is not generally charged as it should be. In this case nothing is charged for room, as separate power rooms are not required.

Table III gives the cost of gas power, using illuminating gas of 760 B. T. U. No estimate is made on the cost of gas power, using producer gas, as it would not pay to put in a gas producer for so small a unit.

In Table IV are given figures on the cost of steam power, from 6 to 20 horse-power, but no estimate is made on the cost for 2 horse-power, for the reason that such a plant would be too small to consider. The figures in Table V show a summarized comparison between the annual cost of power per brake horse-power for various kinds of motive power.

TABLE I. COST OF GASOLINE POWER.

Size of plant in H.P.....	2	6	10	20
Price of engine in place	$150.00	$325.00	$500.00	$750.00
Gasoline per B. H. P. per hour	1-3 gal.	1-4 gal.	1-6 gal.	1-8 gal.
Cost per gallon.....	$0.22	$0.20	$0.19	$0.18
=cost per 3,080 hours.	$451.53	$924.00	$975.13	$1,386.00
Attendance at $1 per day	308.00	308.00	308.00	308.00
Interest, 5%	7.50	16.25	25.00	37.50
Depreciation, 5% ..	7.50	16.25	25.00	37.50
Repairs, 10%	15.00	32.50	50.00	75.00
Supplies, 20%	30.00	65.00	100.00	150.00
Insurance, 2%	3.00	6.50	10.00	15.00
Taxes, 1%	1.50	3.25	5.00	7.50
Power cost	$824.03	$1,371.75	$1,498,13	$2,016.50

To these figures should be added charges on space occupied as follows:

Value of space occupied	$100.00	$150.00	$200.00	$300.00
Interest, 5%	$5.00	$7.50	$10.00	$15.00
Repairs, 2%	2.00	3.00	4.00	6.00
Insurance, 1%	1.00	1.50	2.00	3.00
Taxes, 1%	1.00	1.50	2.00	3.00
Total annual charge for space	$9.00	$13.50	$18.00	$27.00
Total cost per annum	$833.03	$1,385.25	$1,516.13	$2,043.50
Cost of 1 H. P. per annum, 10-hour basis	416.51	239.87	151.61	102.17
Cost of 1 H.P. per hour.	$0.1352	$0.0780	$0.0492	$0.0331

* From Engineering News.

TABLE II. COST OF ELECTRIC POWER.

Size of plant in H.P...	2	6	10	20
Cost of motor in place	$83.00	$118.00	$216.00	$270.00
With wiring, etc...	100.00	130.00	240.00	300.00
Cost of electricity 3,080 hours	$529.56	$976.00	$1,425.00	$2,450.00
Attendance	20.00	30.00	50.00	50.00
Interest, 5%	5.00	6.50	12.00	15.00
Depreciation, 10% .	10.00	13.00	24.00	30.00
Repairs, 5%	5.00	6.50	12.00	15.00
Supplies, 1%	1.00	1.30	2.40	3.00
Insurance, 2%	2.00	2.60	4.80	6.00
Taxes, 1%	1.00	1.30	2.40	3.00
Total cost per annum	$573.56	$1,037.20	$1,532.60	$2,572.00
Cost of 1 H.P. per annum, 10-hour basis.	286.78	172.86	153.20	128.60
Cost of 1 H.P. per hour	$0.0928	$0.0558	$0.0497	$0.0417

The costs for the electric current which are used in Table II are figured from the discount table shown as follows:

COSTS OF ELECTRIC CURRENT.

Base Price = 13½ cents per K.W. hour. Discounts on Monthly Bill.

Monthly Bill.	Discounts.	Monthly Bill.	Discounts.
$5	10%	$100 to $125....	40%
$10 to $20.....	15%	$125 to $150....	45%
$20 to $25.....	20%	$150 to $175....	50%
$25 to $50.....	25%	$175 to $200....	55%
$50 to $75.....	30%	$200 to $500....	60%
$75 to $100.....	35%	$500 and over...	65%

For 2 H.P. plant:

$$\frac{3{,}080 \text{ hours} \times 2 \text{ H.P.} \times 0.746}{82 \text{ per cent Efficiency}} = 5{,}604.1 \text{ K.W. hours}$$

per annum, then 5,604.1 × $0.135 = $756.55, annual cost without discount.

Monthly bill = $63. Discount = 30 per cent.

$756.55 × 70% = $529.56 = annual cost.

For 6 H.P. plant:

$$\frac{3{,}080 \times 6 \text{ H.P.} \times 0.746 \times 0.135 \times 45}{86 \text{ per cent Efficiency}} = \$976.00$$

Monthly cost = $180. Discount = 55 per cent.

For 10 H.P. plant:

$$\frac{3{,}080 \times 10 \times 0.746 \times 0.135 \times 40}{87 \text{ per cent}} = \$1{,}425.00$$

Monthly cost = $298. Discount = 60 per cent.

For 20 H.P. plant:

$$\frac{3{,}080 \times 20 \times 0.746 \times 0.135 \times 35}{88.5 \text{ per cent}} = \$2{,}450.00$$

Monthly cost = $585. Discount = 65 per cent.

TABLE III. COST OF GAS POWER.

$1.50 per 1,000 cubic feet of gas less 20 per cent, if paid in 10 days = $1.20 net, gas 760 B.T.U.

Size of plant in H.P..	2	6	10	20
Engine cost in place	$200.00	$375.00	$550.00	$1,050.00
Gas per H.P. hour in cubic feet.....	30	25	22	20
Value of gas consumed, 3,080 hours ..	$221.76	$554.40	$843.12	$1,478.00
Attendance, $1 per day	308.00	308.00	308.00	308.00
Interest, 5%	10.00	18.75	27.50	52.50
Depreciation, 5% ..	10.00	18.75	27.50	52.50
Repairs, 10%	20.00	37.50	55.00	105.00
Supplies, 20%	40.00	75.00	110.00	210.00
Insurance, 2%	4.00	7.50	11.00	21.00
Taxes, 1%	2.00	3.75	5.50	10.50
Power cost	$615.76	$1,023.65	$1,387.62	$2,237.50
Annual charge for space	9.00	13.50	18.00	27.00
Total cost per annum	$624.76	$1,037.15	$1,405.62	$2,264.50
Cost of 1 H.P. per annum, 10-hour basis	312.38	172.86	140.56	113.22
Cost of 1 H.P. per hour	$0.1014	$0.0561	$0.0456	$0.0367

TABLE IV. COST OF STEAM POWER.

Size of plant in H.P.....	6	10	20
Cost of plant per H.P....	$250.00	$220.00	$200.00
Fixed charge, 14%.....	$35.00	$30.80	$28.00
Coal per H.P. hour, in pounds	20	15	12
Cost of coal at $5 per ton.	$154.00	$103.00	$82.50
Attendance, 3,080 hours..	75.00	50.00	30.00
Oil, waste, and supplies..	15.00	10.00	6.00
Cost 1 H.P. per annum, 10-hour basis	$279.00	$194.80	$146.50
Cost of 1 H.P. per hour..	$0.0906	$0.0832	$0.0475

TABLE V. ANNUAL COST OF POWER PER BRAKE HORSE-POWER.*

B.H.P. of Unit.	Steam.	Electricity.	Gas.	Gasoline.
1	$600.00	$312.50	$380.00	$487.50
2	500.00	282.00	312.50	416.00
3	437.50	252.00	260.00	350.00
4	375.00	227.50	220.00	300.00
5	320.00	207.50	192.50	262.50
6	280.00	192.00	172.50	240.00
7	250.00	179.00	160.00	210.00
8	230.00	168.00	152.50	182.50
9	210.00	158.00	145.00	165.00
10	195.00	152.00	140.00	152.00
12	175.00	140.00	132.50	137.50
14	165.00	133.00	126.00	122.00
16	157.50	128.00	120.00	112.50
18	150.00	126.00	116.50	107.50
20	146.00	123.00	113.00	102.00
22	140.00	121.50	110.00	98.00
24	137.50	119.50	107.50	95.00
26	133.00	117.50	105.00	92.50
28	130.00	116.50	102.50	90.00
30	127.50	115.00	102.00	87.50
35	124.00	113.50	100.00	85.00
40	120.00	112.00	98.00	82.50
50	112.50	110.00	96.00	80.00
60	105.00	108.00	94.00	78.00
70	100.00	106.00	92.00	76.00
80	95.00	104.00	90.00	74.00
90	90.50	102.00	88.00	72.00
100	86.40	100.00	86.00	70.00

Many systems for the electrical control of clocks have been devised, but most of them have proved failures in practice. The causes of failure are generally either the running down of the batteries used to produce the current, or the deterioration of the mechanical contacts in the circuit. In the "Magneta" system of electric clocks, which is installed in the new Town Hall at Lambeth, both these defects have been eliminated. The weight of the master clock actuates not only the master clock itself, but also all the others. At intervals of a minute this weight falls through a very small space turning a copper coil which rotates in a strong field due to permanent magnets. The alternating currents generated by this armature transmit an impulse to every clock in the circuit, moving the hands forward to the next minute. Sir William Preece states that 500 clocks can easily be controlled in this way through 50 miles of wire. The mechanism for propelling the hands of the clocks is extremely simple, and there should be no difficulty in maintaining it in working order. A great advantage of the system is that the secondary clocks require no winding or setting. Magneta clocks are now in use in many public buildings in London and Glasgow, and every one can easily ascertain whether they are giving satisfaction. We are favorably impressed with the simplicity and effectiveness of the electrical and mechanical arrangements.

* Unit cost: Coal, $5 per ton; electricity, $0.135 per K. W.-hour; gas $1.20 per 1000 cubic feet, at 760 B. T. U.; gasoline, $0.20 per gallon.

NEW FORMS OF STEEL FOR NEW USES.*

STRUCTURAL SHAPES RENDERED NECESSARY BY THE STEEL BUILDING.

BY R. B. WOODWORTH.

IT is usually supposed that statistics are of value only to those who take delight in abstruse mathematical calculations without regard to any material use or benefit derived therefrom, and that ordinarily a practical man engaged in the useful pursuit of lucrative employment has little or no interest in them, and yet beyond question, the statistics of an industry constitute an invaluable record of that industry's course and development, and an intelligent analysis of statistics may be of great importance and interest, and may result in the ascertainment of historical facts of value.

Let us take, for example, the production of steel plates and sheets, exclusive of nail plates, in the United States during the period covered by ascertainable records:

	Gross Tons		Gross Tons
1887	603,355	1898	1,448,301
1888	609,327	1899	1,903,505
1889	716,496	1900	1,794,528
1890	809,981	1901	2,254,425
1891	678,927	1902	2,665,409
1892	751,460	1903	2,599,665
1893	674,345	1904	2,421,398
1894	682,900	1905 (plates 2,041,206; sheets, 1,491,024)	3,532,230
1895	991,459	1906 (plates)	2,010,347
1896	965,776	1907 (plates, estimated)	2,025,962
1897	1,207,286		

Up to 1904 the statistics of the American Iron and Steel Association did not distinguish between plates and sheets; in 1905 there were produced a total of 3,532,230 gross tons of plates and sheets composed of 2,041,206 gross tons plates and 1,491,024 gross tons sheets. In 1906 and 1907 the production of plates alone amounted to 2,010,347 and 2,025,962 gross tons, respectively.

Now the statistics of the production of steel plates is in a measure an index to the development of certain classes of construction distinctive of the closing years of the nineteenth century and the inception of the twentieth. Steel as a material for shipbuilding construction was first introduced under modern methods of manufacture during the period from 1870 to 1875, but the first all-steel merchant vessel seems to have been the Cunard liner "Servia," built in 1881, and the first all-steel battleship seems to have been the "Benbow," constructed by the English government in 1885. In the year 1900, however, 93.21 per cent of all the vessels of 100-ton register and over, whether on lake or ocean service, were constructed of steel, and the steady growth of plate production shown in our list marks the gradual development of the shipbuilding industry. This development continued to be gradual until about 1896, about which time the first steel railway car was built by the Keystone Bridge Works. Since that date the rapid increase in plate production reflects the rapid development in the manufacture of steel cars. About 1898 the Schultz Bridge Company, at McKees Rocks, built the first steel barge for river transportation, and the increased use of steel barges on our rivers has added its quota to the increased production of steel plates.

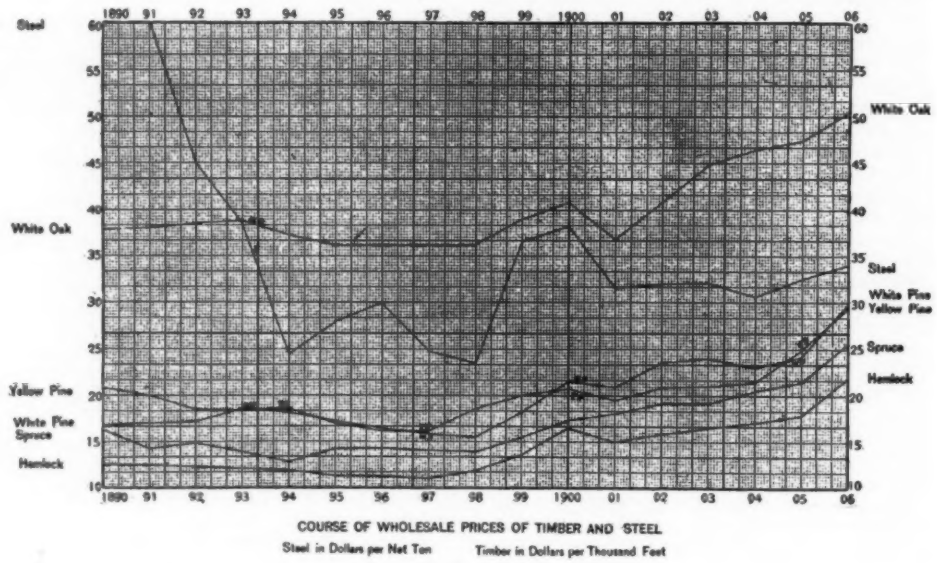

Steel
White Oak
Yellow Pine
White Pine
Spruce
Hemlock
1890 91 92 93 94 95 96 97 98 99 1900 01 02 03 04 05 06
COURSE OF WHOLESALE PRICES OF TIMBER AND STEEL
Steel in Dollars per Net Ton
Timber in Dollars per Thousand Feet

FIG. 1.

The production of steel shapes, meaning by that beams, beam girders, zees, tees, channels, angles, etc., is an index to the development of the steel bridge and especially of the steel building. In 1884 the first 15-inch steel beams were rolled at Upper Union Mills. They were followed by the rolling of 20-inch beams on the 33-inch mill, Homestead Steel Works, January 3, 1888; 24-inch beams on the 33-inch mill, Homestead Steel Works, June 19, 1889, and 18-inch beams on the 35-inch mill, Homestead Steel Works, February 3, 1897. The rolling of these sized beams has made possible and economical the skeleton steel building, and the production of shapes has grown in accordance with the growth of the modern office building in the principal cities of the United States. The production is as follows:

	Gross Tons		Gross Tons
1892	453,957	1900	815,161
1893	387,307	1901	1,013,150
1894	360,305	1902	1,300,326
1895	517,920	1903	1,095,813
1896	495,571	1904	949,146
1897	583,790	1905	1,660,519
1898	702,197	1906	1,707,636
1899	850,376	1907 (estimated)	1,627,642

It may be said, however, that the skeleton steel building is a vital necessity within large commercial centers, and that the commercial expansion of the United States would of itself have compelled the erection of these buildings regardless of the use of steel in their construction. The point now made is that the use of steel has made economical their construction, and while causes act and interact among themselves, yet beyond question a low-priced economical material is the essential condition of building construction. When steel was not the convenient material it is, other forms of construction may have taken its place, but as matters stand to-day, steel is the only material known to the engineering profession which is absolutely homogeneous in all particulars, of unquestioned strength and reliability, easy to fabricate and erect, convenient and satisfactory in all respects.

Besides its unquestioned economy, there are two considerations which have led to the large use of steel as the ideal building construction. The first of these which we will mention is its fireproof character. This is not the principal reason, but beyond question it is a very important one.

George E. Walsh has spoken of our country as "Combustible America," and a consideration of the facts in the case prove the correctness of that designation. Our annual fire bill has been steadily growing as our population increases. In 1905, for example, building operations throughout the country represented a total investment of $525,000,000, and in 1906, the high-water mark in the nation's history, $700,000,000. In 1904 our fire losses alone aggregated $229,198,050. In 1906 the losses in the United States and Canada by fire were $536,860,400. Of this last sum San Francisco was responsible for $350,000,000, including buildings and contents. We speak of the spectacular burning of Rome in the days of Nero, and the great conflagration of ancient London, but these are not to be mentioned in the same breath with the fires of Chicago, Baltimore and San Francisco. The destruction of property by fire is only a part of the losses entailed on our country.

Our people have borne their fire losses and have rebuilt the same kind of structures until it has become fully realized that the part of wisdom lies in the construction of buildings which are in themselves fireproof, and that wiser economy is found in the construction of better buildings than in decreased first cost. Consequently while the number of fireproof buildings is still really small, even in our largest cities, yet beyond question the requirements of fireproof construction have been and will continue to be

* Read before the Engineers' Society of Western Pennsylvania.

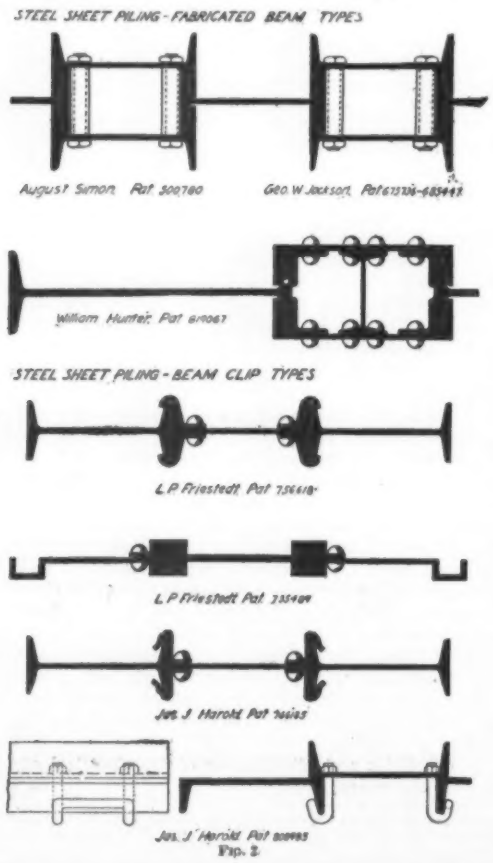

STEEL SHEET PILING - FABRICATED BEAM TYPES
August Simon Pat 909780
Geo. W. Jackson, Pat 623208-683443
William Hunter, Pat 611067
STEEL SHEET PILING - BEAM CLIP TYPES
L. P. Friestedt Pat 756618
L. P. Friestedt Pat 735409
Jos. J. Harold Pat 746163
Jos. J. Harold Pat 808693

FIG. 2.

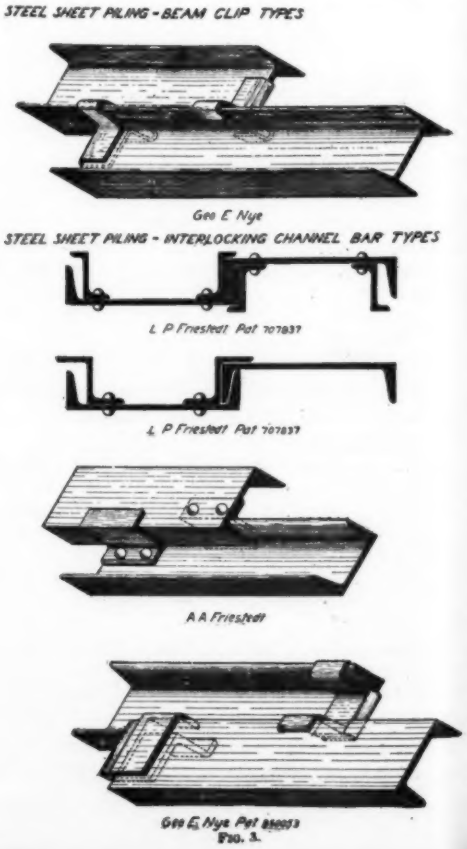
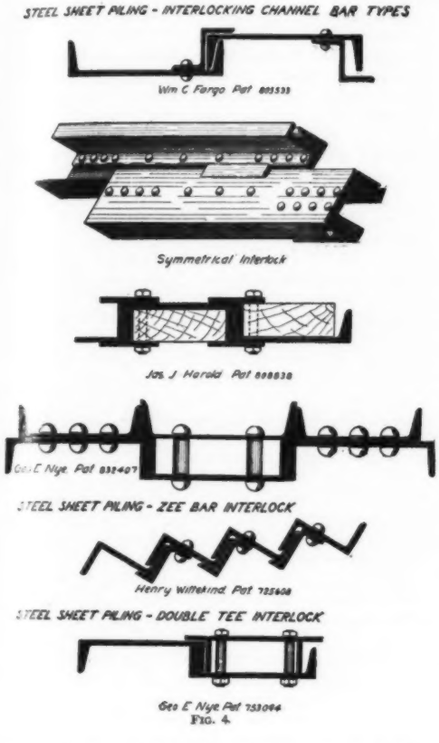

STEEL SHEET PILING - BEAM CLIP TYPES
Geo E. Nye
STEEL SHEET PILING - INTERLOCKING CHANNEL BAR TYPES
L. P. Friestedt Pat 707837
L. P. Friestedt Pat 707837
A. A. Friestedt
Geo E. Nye Pat 816693

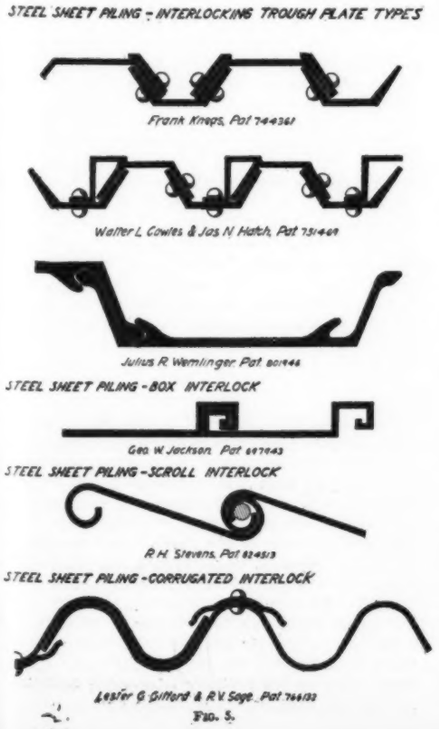
FIG. 3.

large factors in the extension of the use of steel. The evolution in building which has not yet reached its culmination, dates back to the first introduction of rolled I-beams of iron in France and Belgium in 1854, but the famous Chicago fire showed the unreliability of unprotected iron beams in a hot fire. Unprotected steel is a better fire-resisting material than protected


STEEL SHEET PILING - INTERLOCKING CHANNEL BAR TYPES
Wm C Fargo Pat 805533
Symmetrical Interlock
Jos J Harold Pat 808838
Geo E Nye Pat 833407
STEEL SHEET PILING - ZEE BAR INTERLOCK
Henry Wittekind Pat 725408
STEEL SHEET PILING - DOUBLE TEE INTERLOCK
Geo E Nye Pat 753044
FIG. 4.

iron, but the ideal modern building is a skeleton structure of steel fully protected by refractory materials, which, by reason of being once burnt, are in a position to resist successfully, as they have done in numerous instances, the hottest temperature an office or warehouse building can develop.

The chief factor, however, which has occasioned great extension in the use of steel bridges and buildings has been the rapid increase in the cost of timber, as well as the great decrease in the quality of the timber which actually comes on the market, and in this connection the annexed table and drawing Fig. 1, showing the course of wholesale prices prepared from statistics furnished by the Bureau of Commerce and Labor, demonstrates very plainly that the price for lumber per thousand feet is gradually approaching the price of steel per ton, and that if conditions now in force continue, the difference between steel and wood will be quickly diminished.


STEEL SHEET PILING - INTERLOCKING TROUGH PLATE TYPES
Frank Kneps, Pat 744361
Walter L Cowles & Jas N Hatch, Pat 751469
Julius R Wemlinger Pat 801446
STEEL SHEET PILING - BOX INTERLOCK
Geo W Jackson Pat 667643
STEEL SHEET PILING - SCROLL INTERLOCK
R H Stevens, Pat 824513
STEEL SHEET PILING - CORRUGATED INTERLOCK
Lester G Gifford & R V Sage Pat 766133
FIG. 5.

COURSE OF WHOLESALE PRICES.

	Hemlock.	White Oak.	White Pine.	Yellow Pine.	Spruce.	Steel.
1890	12.58	37.88	16.79	20.75	16.29	60.00
1891	12.46	38.00	17.00	19.96	14.22	60.00
1892	12.29	38.46	17.15	18.50	14.85	45.00
1893	12.00	38.75	18.62	18.50	13.77	38.60
1894	11.71	37.25	18.17	18.50	12.71	24.65
1895	11.15	36.25	17.25	16.92	14.25	28.00
1896	11.17	36.25	16.50	16.42	14.25	29.90
1897	11.00	36.25	15.83	16.44	14.00	24.75
1898	11.75	36.25	15.50	18.62	13.75	23.45
1899	13.52	38.96	18.20	20.04	15.40	36.60
1900	16.50	40.83	21.50	20.71	17.38	38.20
1901	15.00	36.77	20.88	19.67	18.00	31.55
1902	15.83	40.88	23.50	21.00	19.25	32.00
1903	16.79	44.83	24.00	21.00	19.19	32.00
1904	17.00	46.50	23.00	21.42	20.50	30.60
1905	17.88	47.33	24.17	24.92	21.42	32.60
1906	21.90	50.42	29.75	29.33	25.54	54.00

The price of steel beams and channels is given f. o. b. cars, Pittsburg, in dollars per ton of 2,000 pounds. Prices for lumber are given in dollars per thousand feet board measure. Prices for hemlock are based on 2 x 4 pieces 12 to 14 feet long, Pennsylvania stock f. o. b. New York. Prices of white oak are for 1 x 6 boards, same place. Prices of white pine are for No. 2 barn grade, 1 x 10 rough, f. o. b. cars, Buffalo. Yellow pine prices are for 1 inch long leaf boards, f. o. b. cars, New York, and spruce 6 feet to 9 feet cargoes, New York city. It is to be noted that since 1897, a year of great industrial depression, the price of timber of the grades used in building has practically doubled, and while the price of steel has been subject to great fluctuations and stands to-day, due to improvements in manufacture, at relatively low figures, the price of lumber has steadily increased.

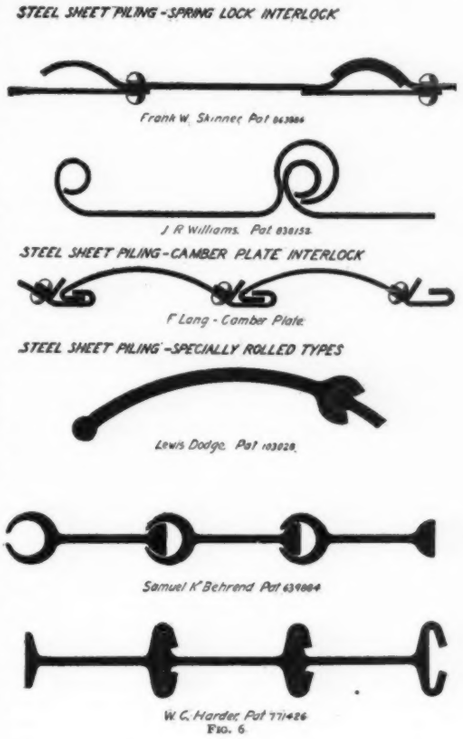
Among other things, this chart shows very plainly that the prices of timber per thousand feet and the price of steel per net ton have approached very closely to each other; that the question of comparative cost is not to-day the feature it was ten years ago, and that the comparative first cost of wood is not very much of an item when compared with the much longer life of steel, its much more satisfactory character and its convenience in manufacture and erection; and beyond doubt the development of the immediate future lies in the rapidly increasing substitution of steel for wood in all classes of ordinary building construction. Of course, in the modern building, some place will be taken by reinforced concrete, which is a material that offers numerous advantages for those places in construction for which it is peculiarly suitable. It cannot, however, take the place of steel, and the building laws of our best cities have begun to reflect the prevailing opinion of the engineering profession to the effect that reinforced concrete must be used under conditions of the most careful manufacture and inspection, and that even when so used, its use on high buildings must necessarily be restricted. There is no restriction to the use of steel.

It would be very interesting to touch upon quite a number of the uses of steel, which distinctly mark the beginning of the twentieth century. Iron has given place to soft steel in the manufacture of all kinds of agricultural shapes and machinery. Special forms of steel are used in the manufacture of turbine plates for the construction of the turbine, so prominent in transmission line construction. Steel wheels, whether cast or forged, or steel tired, are rapidly taking the place of the ordinary iron castings, and we hear no more of the compressed paper wheel, which, it will be recalled, was seriously advocated some years ago. Our heaviest and best trains, composed of steel cars and coaches, are carried safely over roadbeds constructed of steel ties. The steel tie has not yet supplanted wood, but beyond question will form the ideal roadbed of the future.

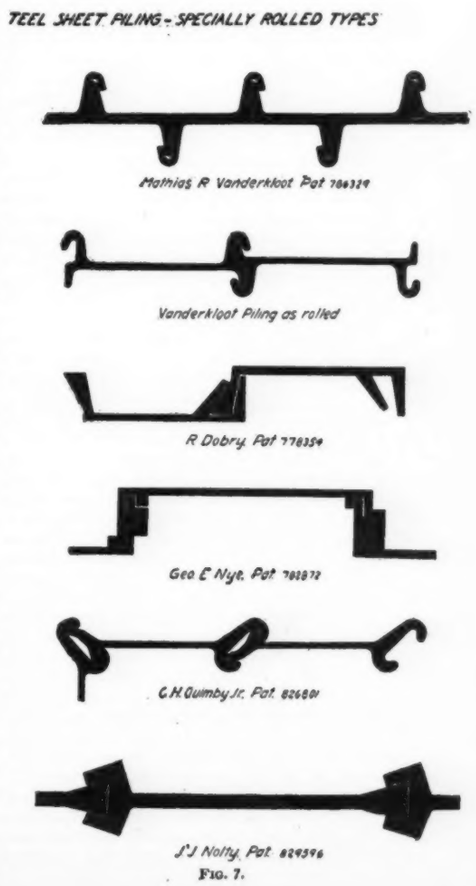
The production of structural shapes in this country, as has been stated, reflects accurately the expansion of steel construction in buildings and bridges, or the increasing use of steel in that class of construction which deals with the superstructure. It is confidently believed that the application of steel for use in the construction of foundations, cofferdams, etc., will play a large part in the shape and plate production of the future. We have to speak, therefore, of modern methods of substructure construction, which offers large place for the substitution of steel for wood.

FABRICATED BEAM TYPE.

Round piles of cast iron seem to have been in use as early as 1822, but the invention and application of forms of steel sheet piling has fallen chiefly within the present twentieth century. These forms have varied as the inventors were numerous, and it is difficult to classify satisfactorily all the various types of steel sheet piling which are presented in the documents which have passed through the Patent Office covering this class of construction. There are, however, certain outstanding types which will be mentioned. First, the fabricated beam type. This type consists in the main of two standard beams or channels connected together by bolts and separators to form what might be called a box pile, the boxes being connected together in a straight line by standard beams or channels, the flanges of the single beams forming this connection interlocking with the flanges of the beams or channels forming the box. This type of construction was first shown in letters patent 500,780, granted on July 4, 1893, to August Simon, of Gnadau, Germany, and the basal ideas of August Simon reappeared in the improvements made thereon in patents 675,736, of June 4, 1901, and 685,447, grant-


STEEL SHEET PILING - SPRING LOCK INTERLOCK
Frank W Skinner Pat 843964
J R Williams Pat 838152
STEEL SHEET PILING - CAMBER PLATE INTERLOCK
F Lang - Camber Plate
STEEL SHEET PILING - SPECIALLY ROLLED TYPES
Lewis Dodge Pat 103028
Samuel K Behrend Pat 639684
W C Harder Pat 771426
FIG. 6.

ed October 29, 1901, to George W. Jackson, and it is to be noted that the first steel sheet piling used in the United States and driven in November, 1901, at Randolph Street Bridge, Chicago, Ill., was of this type, which affords large possibilities in heavy submarine construction, but at the same time is deficient in its ability to furnish light-weight sections for ordinary cofferdam and sewer construction. The driving of the Jackson piling demonstrated the necessity of some provision to make the piling water-tight, and Jackson and Hogan patent 758,856, of May 3, 1904, shows this


TEEL SHEET PILING - SPECIALLY ROLLED TYPES
Mathias R Vanderkloot Pat 786329
Vanderkloot Piling as rolled
R Dobry Pat 776354
Geo E Nye, Pat 788872
C H Quimby Jr. Pat 826801
J J Nolty, Pat 829396
FIG. 7.

feature of the fabricated beam type steel sheet piling. The further development of this type of piling is to be found in the ideas of William Hunter, of Kincardine, Ontario, as recorded in patent 819,067, which consists essentially of a series of steel columns built up of beams and channels and connected together by heavyweight I-beams, which would make a form of construction that would be extremely difficult to drive and about four or five times as heavy as there is any need for, but which after it has reached its final position in the construction, would have the strength of Gibraltar.

BEAM CLIP TYPE.

The excessive weight of the fabricated type of beam piling led inventors to consider the use of beams aligned successively with the top flange of the one against the bottom flange of the other, which I call the beam clip type. This is represented in patent 756,618 granted to L. P. Friestedt, of Chicago, on April 5, 1904, in which regular structural beams are used to form an interlocked wall. The weight of this section, however, caused Mr. Friestedt to turn his attention to a lighter form of construction based on the same idea. This is described in patent 735,489, dated August 4, 1903, in which the place of beams has been taken by sections either round or square headed and similar to the bull-head rails in use on the railways of England. Mr. Friestedt's original ideas have proven fruitful in stimulating others to action, and James J. Harold, of Jersey City, N. J., has taken out patents 766,185 of August 2, 1904, 807,378 of December 12, 1905, and 820,970 of May 22, 1906, in all of which the same idea occurs of connecting together standard beams assembled edgewise by clips which may be riveted either to beams themselves, or to a plate (Fig. 3). The latest development in the idea of connecting standard beams by clips, either full length or of short pieces, appears in the latest patents taken out by George E. Nye, of Chicago, Ill.

FRIESTEDT INTERLOCKING CHANNEL BAR PILING.

The beam clip type of piling, however, in spite of its simplicity and strength, due to its large radius of gyration, suffers from the same criticism already made on the use of beams in piling construction, namely, that due to the weight being beyond absolutely necessary requirements. It is this consideration which has called forth interlocking channel bar piling, which appears in different forms, but all of which are due in the ultimate analysis to the inventive genius of Mr. L. P. Friestedt, of Chicago, and the success of which in a large measure has made steel sheet piling one of the indispensable factors of substructure construction. Mr. Friestedt's basal patent is No. 707,837, granted August 26, 1902.

Patent 730,755 of June 9, 1903, 733,713 of July 14, 1903, 733,314 of July 21, 1903, and 834,051 of October 23, 1906, show extensions and applications of Mr. Friestedt's original basal patent, and present modifications covering constructions adaptable to corners, etc. The first of the Friestedt interlocking channel bar piling was driven in October, 1902, in the mine shaft of the Johnson City and Big Muddy Coal and Mining Company, at Johnson City, Ill., and its increasing use by the engineering and contracting profession has demonstrated the correctness of the ideas on which it was based.

In the endeavor to get away from the weight due to use of zees extending the full length of the channels and forming a continuous interlock, the idea has arisen that it might be possible to use short pieces. This has given rise to the *clip interlock*, which appears in the first instance in patents 734,843 of July 28, 1903, and 739,072 of September 15, 1903, granted to L. P. Friestedt, and covering frictional pieces to wedge the steel piling members closely together, and at the same time to do away with the excess weight. This idea had hardly passed into history before it was followed by patent 808,985 granted to James J. Harold, of Jersey City, on January 2, 1906, in which a clip interlock is formed by double U-bolt connecting adjoining channels or beams together. Mr. A. A. Friestedt has patented a clip successor to the full length interlock, his idea being to use short length zees simply to guide the channels in driving and to depend upon the frictional resistance of the channels themselves and earth or water pressure to form a continuous interlock. Mr. A. A. Friestedt's ideas have been reflected in patent 860,053 of July 16, 1907, and 871,177 of November 19, 1907, granted to George E. Nye, of Chicago, in which the clips are formed not of rolled zee bars, but of steel castings approximating the zee bar shape. Exeprimental tests with the clip form of steel piling have shown that while it may be admirably suited to light, easy driving in shallow soils, it cannot be depended upon for heavy work through quicksands, boulders, or other closely-compacted material, for the reason that inasmuch as the channels are fastened together only at the top and bottom, the driving of the piling to a refusal will necessarily tend to cause the channels to buckle about their middle and open out, thus destroying any effective interlock, and resulting, in submarine work, in excessive leakage which cannot be stopped except by expensive means, which produces undue delay in operation.

There is an advantage in the clip interlock in having zees on each piece to hold material in exact alignment.

Mr. William G. Fargo, of Jackson, Mich., had occasion to use in the construction of the dam for the Grand Rapids-Muskegon Power Company quite a quantity of Friestedt interlocking channel bar piling under difficult conditions of driving. He discovered very shortly the inherent weakness of the Friestedt interlocking channel bar piling, which consists in the fact that the plain channel composing the alternate section has but a small radius of gyration and shows a tendency to buckle under heavy driving. To obviate this disadvantage, Mr. Fargo had fabricated by the Friestedt Company a quantity of piling which differed from that covered by the Friestedt basal patent in having a single zee bar riveted to each piece instead of two zees riveted to alternate sections. By this means he succeeded in making each piece of the same strength and found that the most difficult driving could be satisfactorily accomplished. His ideas have been covered by patent 805,533 dated November 28, 1905.

(To be concluded.)

A NEW BLUE-BLACK PROTECTIVE IRON PAINT FROM "WASTE PICKLE" SOLUTIONS.

A PLANT has been erected in England for the purpose of commercially developing the interesting discovery that has been made by Dr. C. F. Wüffling for the production of a new blue-black iron paint which has been found to possess very efficient protective qualities. As is well known, in the preparation of iron and steel rods for wire drawing, and also of plates for tinning, the metal has to be submitted to preliminary immersion or pickling in an acid bath for the purpose of removing the scale formed during the preparation of the iron and steel. This pickle is composed of either sulphuric acid or hydrochloric acid, and the action of the latter upon the metal produces solutions of sulphate of iron and chloride of iron respectively.

Various efforts have been made to turn these waste solutions to commercial advantage, but with only partial success. The most generally practised method is to produce sulphate of iron or copperas. As the sulphuric acid when it has completed its allotted function is not completely neutralized, it is killed by the addition of scrap. This yields a neutral solution from which the copperas can be obtained in a solid form, the main supplies of which product are obtained in this manner. When hydrochloric acid is employed as the pickling agent, however, the ferrous chloride which is produced cannot be so easily recovered as the copperas, and moreover has no great commercial value.

Consequently, in dealing with this liquor some base is generally added to it to combine with the chlorine and to precipitate the iron as an oxide. For this purpose lime, as the most obvious base, is used, but here again the sodium chloride which is produced is of no commercial value. Other expedients have been tried, but without any success.

Dr. Wüffling, however, during his residence in the center of the Welsh tinplate industry embarked upon a series of experiments with ammonia, in order to secure the desired precipitation and at the same time the by-product ammonium chloride. He was stimulated in his researches by the fact that such a residue is of greater value than the ammonia used for the purpose. There was one great obstacle that had to be overcome. That was, owing to the volatile nature of his precipitating agent, special apparatus which would prevent the escape of any of the ammonia was necessary. As a result of his experiments, however, he succeeded in devising a special type of closed vessel in which the operation can be carried out without any appreciable loss of the ammonia.

When the ammonia has been added to the hydrochloric pickle, a current of air is directed through the vessel for a considerable time, the object of this oxidation being to secure a black oxide of iron, such as is only obtainable after long exposure to the air blast. The oxide thus obtained is of a beautiful blue-black color, is quite insoluble in water, and when passed into the filter press leaves a perfectly clear solution of ammonium chloride. This is afterward evaporated and then allowed to crystallize. The blue-black precipitate is magnetic, showing it to be Fe_3O_4, and is a valuable addition to the list of pigments that can be utilized for the protection of structural ironwork.

If the chloride liquors are treated with other bases a black color can be obtained, but it is not of the extreme fineness characteristic of the utilization of ammonia. Moreover, the fact has to be remembered that whatever method is employed, absolute chemical purity cannot be attained. For instance, if the process be carried out with lime, some remains behind, and this is a most undesirable impurity, the resultant color moreover being of poor quality. On the other hand, with ammonia, the black oxide is left with a trace of double salt which the inventor regards as NH_4Cl, $FeCl_2$. This acts beneficially on the paint, although ammonium chloride by itself would not do so.

The pigment is made up with boiled linseed oil and applied to the structure in the usual manner. Several tests have been carried out with the material, and complete success has been obtained. Iron buildings treated with the blue-black oxide of iron some two years ago still retain their original varnish-like surface, despite exposure to varying weathers, which have so far failed to exercise any deleterious effect upon the paint.

WHAT THE DESTRUCTION OF FORESTS MEANS IN THE FAR WEST.

THE destruction of forests in the far West was the subject of some interesting observations by Mr. Alfred B. Iles, a well-known mining engineer. Mr. Iles gives it as his opinion that there is no part of the Union that is suffering more from the destruction of our forests than that portion surrounding the mining towns of the Rocky Mountains. The ever-increasing demands of the mines has resulted in stripping the landscape of every vestige of timber, and at the rate it is disappearing there will be very little desirable timber left in twenty years from now. The growth of deep mining means a heavier consumption of timber, and to supply the demand is one of the perplexing problems of the day.

The stripping of the mountain sides leaves them as bare and bald as an iceberg, and while in a few instances cultivated fields and thrifty homes have supplanted the forest, the stripped lands are abandoned as irredeemable waste.

The young shoots of evergreen, spruce, pine, and fir that escape the snow slides are of slow growth, and even if they are not destroyed, they will require nearly a century to become large enough for mine and lumber purposes. By every means possible we should protect our mountain forests from destruction.

The more timber the more moisture, more snow in winter and more rain in summer. Timber helps to temper the climate and keep the streams flush with water. Less than half the water is running down the mountain now that there was forty years ago. Then ten feet of snow followed by a rainy season from June to September was common; now it is a rarity. We have but a fling of snow and the rainfalls are light. The result is that the winters are much colder and frigid and the summer hotter and more arid.

What with the lumber mills, paper mills, tie cutters, forest fires, and other destructive agencies, it will not be long before we shall have to draw upon British Columbia and Alaska for supplies; in fact, some of our great railways are already in the northern field buying up large areas of timber.

The denudation of the forests of Michigan, Minnesota, and Wisconsin during the last thirty years has caused a decrease amounting to fifty per cent in the flow of the streams that empty into the Mississippi, and the lakes fed by these waters have been lowered five feet.

Where these great pine forests once stood in all their glory dead stumps and tree tops now mark the country, and to complete the devastation extensive fires break out every summer and sweep over vast areas, destroying every green thing and leaving in their wake a barren scene of desolation. No wonder the streams are falling, the great lakes losing their mighty volume, and the country drying up. The brand of Cain is upon it, and a barren desert is the fruit of man's greed and his remorseless destruction of the crowning glory of the earth.

True, the greater portion of the product of these forests has been utilized, and to that extent has enriched the industries of the country. But on the other hand, there has been a great and unnecessary waste of timber, through avoidable forest fires, the unlawful denudation of vast regions, and the malicious destruction of millions of acres by renegades who delight in starting prairie and forest fires in order to watch their illumination and boast of their destruction.

The repairs to cables in the Mediterranean, says Electrical Engineering, have not yet been effected, and it must be presumed that the breaks are of a more serious nature than was supposed. There are no interruptions to submarine cables to announce, nor restorations to notify. The only disturbance which has taken place is on the lines of the Indo-European Telegraph Company, whose system has suffered interruption between Tauris and Teheran, but it is probable that this is due to the disturbed state of the country where the break has occurred. There may, of course, be other disturbances, but those companies which own duplicate routes are in the habit of keeping them quiet, as the ordinary telegraphic facilities are not thereby impaired or the charges per word altered.

THE WEIGHT OF MARINE TURBINES.

WHAT ARE THE BEST DIMENSIONS FOR A TURBINE?

THAT the weight of marine turbine machinery has been greatly increased during the last two or three years is well known, and as the tendency is still toward increase without any proportionate gain in economy, it may be as well to examine the causes which have led up to this, and indicate some means whereby it can advantageously and safely be reduced. To some extent a considerable increase was necessary on account of the absolute unsuitability of the original marine installations to the commercial necessities of marine engineering. For instance, in many vessels the replacing of a broken gland ring, involving a few minutes' work in a reciprocating job, necessitated lifting the cylinder cover and rotor from the turbine. A large increase in weight of astern turbines was also necessary, the early turbine vessels being lamentably deficient in maneuvering power. More rigid cylinder and rotor construction was also desirable, and in the case of the new Cunarders and the ocean-going destroyers, it was found necessary to greatly increase the blade sections as the stress in these, due more especially to end thrust, was exceptionally high. All this involved increase of weight for the same power and speed of rotation, and developments in propeller design involving greatly reduced revolutions added still more. For the same efficiency, the weight of a turbine of a given power will vary inversely as the square of the revolutions, so that a reduction from 500 to 400 revolutions per minute, brought about by the more advantageous use of a larger propeller, involves an increased weight of over 60 per cent. The use of much heavier cylinders than Parsons originally tried was due to substitution of cast iron for cast steel. Not only were cylinders extremely hard to obtain in the latter metal—the "Amethyst" had numerous failures before a good one was secured—but cast steel has an awkward habit of warping, and distortion of cylinders has accounted for endless blade stripping. In warships the use of cruising turbines has greatly augmented the weight per horse-power. Lagging, thrust adjustment gear, oil-cooling and pumping systems, outside glands with mazes of valves and pipes for a most complicated steam packing system, are all items that have been enormously increased without attracting much notice. It is very simple to advocate reduction, but the fact is that in the early stages the marine turbine, whatever future promise it had in store in the eyes of those that were first acquainted with it, was a crude and undeveloped machine that needed a great deal of modification before it was made commercially suitable. That modification meant increasing the weight.

The following table gives the weights of turbine machinery only, excluding all auxiliaries, condensers, or shafting for various classes of vessel:

WEIGHT OF TURBINES PER HORSE-POWER.

Type of ship.	Shaft. H. P.	Revolutions.	Wght. of turbine tons.	Wght. per H. P. lb.
Battleship	25,000	320	450	40.4
Battleship, proposed ...	28,000	275	540	43.2
Small cruiser	14,000	500	180	28.8
Torpedo boat destroyer.	18,000	700	80	10.0
Torpedo boat destroyer.	4,000	1,100	18	10.1
Channel steamer	12,000	500	110	20.5
Atlantic liner (type)...	42,000	250	900	48.0
Intermediate steamer...	10,000	350	180	40.25

That the present weight of machinery can be greatly reduced there can be no doubt whatever, but it involves a very much clearer appreciation of the functions and performance of the numerous details in an installation than now appears to be possessed in some quarters.

Commencing with the turbine cylinder, in nearly all cases do we find circumferential ribs of some kind; either the half round rib, typical perhaps of East Coast practice, or the heavy bulb rib that has distinguished Clyde cylinders for years. A turbine cylinder after all is a pipe in the position of a beam fixed at the after end and free to slide (supported) at the forward end. When working it is under gradually decreasing internal pressure. Who would rib a pipe, and if so, what use are bulb ribs if half-round ones do, as has been amply proved? What use, in any case, are the shallow half-round ribs? This, at least, is a point on which practice is not only not consistent, but not apparently correct in its policy from the beginning.

Then again, take the test pressures enforced. Without mentioning names, we can quote instances of admiralties or registration societies, acting doubtless on the recommendations of their technical advisers, who insist that a high-pressure cylinder shall be tested to one and a half times the boiler pressure, and that the forward end of the low-pressure cylinder shall be tested to one-fifth the boiler pressure. "Escape valves will be fitted at the after end of the high-pressure cylinders," says the specification. Now, with a boiler pressure of 250 pounds this means that the cylinder end and the last expansion of the high-pressure have to withstand 375 pounds per square inch, while the end of the low-pressure and its first expansion, which, when working, are dealing with an identical pressure to that in the end of the high-pressure, have only to withstand 50 pounds per square inch. Assuming this turbine to be working between 185 pounds per square inch and 28 inches vacuum, the maximum working pressure in the receiver pipe will only be between atmosphere and 5 pounds gage; so that even without the escape valve, the test pressure is enormously exaggerated. This is another direction in which weight can be safely reduced by proper appreciation of the function of the various parts. The two cylinders effect the expansion of steam in six stages in each, twelve in all, or, say the first four correspond to the high-pressure cylinder, the last two in the high-pressure and first two in the low pressure corresponding to the intermediate cylinder of a reciprocating engine. Even in the days of 300 pounds pressure and Belleville boilers, no one was found to require a water pressure test of more than 200 pounds per square inch on an intermediate cylinder, or only about half what the much larger turbine barrel has to stand. These high test pressures, quite apart from adding to weight, are objectionable on the grounds of causing permanent deflection in the castings. It is consequently never possible to put this pressure on after the cylinders have been finished in the boring machine.

Many of the foremost marine engineers in the country are greatly against the system now so generally adopted by the Admiralty of making sets of engines for different ships interchangeable. Whatever its military advantages may be, there can be no doubt that it does not make for thoroughly careful design on the part of one firm when it knows that all its drawings will be given to another firm to work to, however amicably they may arrange the interchange. That basic plans should be got out by one company and adhered to "by command" can only restrict progressive design, and we are not surprised, therefore, when we find a fault made in one design carefully duplicated in several others. Unnecessary length between bearings, excessive scantlings in cylinder end pedestals, thrust blocks, or bearing covers, should all be subjected to far keener criticism from the manufacturers' point of view than is at present encouraged by the existing system.

Less remains to be done in the way of reducing the weight of rotors in existing designs than in the case of cylinders. The essential drum and end spindles will remain, but some alteration will probably take place in the form of wheel adopted for connecting the two. A cast steel hollow-spoked spindle has up till recently been adopted, this form having been calculated as being best adapted to resist compression and twisting on a given weight of material. The recent trouble, however, with the cast steel rotor wheels of H.M.S. "Superb" has resulted in an order being placed for this item in forged steel, though with practically no difference to the weight.

Although somewhat outside the weight of turbines proper, the condensing plant forms no inconsiderable portion of the total weight. The design of marine condensers at present reflects little credit on the engineers responsible, some of the condensers in the destroyers being nothing beyond circular or oval boxes of tubes. Less water and pumping power and much smaller condensers will result when the—somewhat obvious—fact is grasped that an efficient square foot is of more use than many square feet of not only useless but harmful surface. A great deal remains to be done in leading the steam properly among the tubes, and steam speeds and passages need much revision. When this is done, and the surface in a condenser made as equal in efficiency as possible all over, the size and weight of condensing plants will also be much reduced. The arrangement of exhaust pipes to the condenser in most marine installations is not one that is well adapted for distributing the steam properly over the tubes. Adequate area is seldom or never allowed through the tube rows nearest the inlet, and much greater condensing efficiency must obviously result from a more equable distribution of work throughout the condenser.

The size of steam piping and valves merits attention with turbine machinery, the permissible speeds of steam and exhaust being much higher, thereby admitting of reduced pipe diameters. The fall of pressure between the throttle valve and turbine is constant, whereas in a reciprocating engine the closing of the slide valve induced a pulsating effect that demanded a slow speed of delivery. A very slight pressure drop is sufficient to cause a steam speed far in excess of that academically laid down in text books for the diameter of steam pipes.

Many other points might be cited, but in dealing with the above we have been careful to bear in mind specific cases of exaggerated dimensions or unsuitable proportions in recent practice. What we now desire to call attention to has reference to future practice more particularly, though the matter has for long enough been fully realized in certain specialist circles.

From the point of view of weight, cost, and efficiency, the determination of the best dimensions of the marine turbine depends on the accuracy with which it is proportioned to the work it has to perform, and on the correctness with which the balance between the turbine and the propeller is struck. We have numerous cases in which the propeller is too large, or rather larger than is advisable for the turbine, but far more frequently do we find an unnecessarily powerful turbine. Setting aside for the moment the determination of relative proportion, the first step must at least be to determine propeller dimensions for any given power, speed, and number of screws. A simple calculation shows the difference that may be made by the adoption of very slightly different ratios and pressures in the same type of design. Take a Channel steamer of 24 knots speed and 12,000 shaft horse-power. The propeller efficiency is known to be about 50 per cent. There will be three shafts,

$$\text{Effective horse-power} = 12{,}000 \times 0.5 = 6{,}000,$$

$$\text{Effective thrust} = \frac{6{,}000 \times 326}{24 \times 0.95} = 85{,}700 \text{ pounds.}$$

where 0.95 is the wake factor

Some designers will allow a thrust pressure per square inch projecting area of 11 pounds in association with a projected surface ratio of 0.45, while others would go to 11.5 and a surface ratio of 0.5. The resulting diameters would be 7 feet 1½ inches and 6 feet 4½ inches respectively, and with a pitch ratio of 0.95 and 20 per cent slips in each case the revolutions would be about 450 and 500 per minute respectively. The greatest care must be taken to use pressures and proportions that admit of efficient high speeds, as in this case one turbine set will weigh approximately 15 to 20 per cent more than the other.

Equally important is the accurate determination of effective horse-power necessary to propel a given ship at a given speed. There are innumerable instances of this being exaggerated in the design and the vessel attaining an unlooked-for speed. One of the latest cases is undoubtedly that of the United States cruiser "Chester" which was designed for 24 knots and obtained 26.52, an increase in speed corresponding to about 33 per cent in power. Another case is that of the "Tartar," which was designed for about 15,000 shaft horse-power and gave 20,000. To some extent the boilers may have been too generously proportioned, but in each case the turbine was either able to pass over 30 per cent more steam than it was designed for, or else, for its designed power, it was unnecessarily large. In the above example, taking 11 pounds and 0.45 surface ratio as a basis, should one designer estimate the E.H.P. required at 5,500, and another at 6,500, the difference in speed of rotation would be 470 and 430 revolutions respectively.

This is a subject upon which much more might be said. The accurate determination of horse-power required to propel a given ship is of the greatest importance, affecting as it does the entire vessel. More especially does this apply to turbine work, where the area of the propeller is such an essential feature in the design. Recourse should be had, whenever possible, to an experimental model tank. As we have tried to show, the matter does not end here; careful attention to the details of a design should not be relaxed for a single moment.—The Engineer.

Adhesive for Gummed Papers That Will Not Curl.—250 parts of gelatine is steeped over night in water, and 125 parts of gum arabic is dissolved cold in some water; after the gelatine has been melted in the water bath add 50 parts of sugar, 10 parts of glycerine, and the dissolved gum arabic, the whole being made up with water to 1,000 parts. Must be applied while still lukewarm.

PURIFICATION OF AIR BY MEANS OF OZONE.

A DESCRIPTION OF NEW APPARATUS.

BY DR. G. ERLWEIN.

THE fact that ozone is an efficient destroyer of odors of every kind is now generally recognized, and ozone is already employed extensively for purifying the air of rooms. The question whether ozone, as it is used for this purpose, exerts a germicidal, as well as a deodorizing and oxidizing action, cannot be answered until special bacteriological researches have been made.

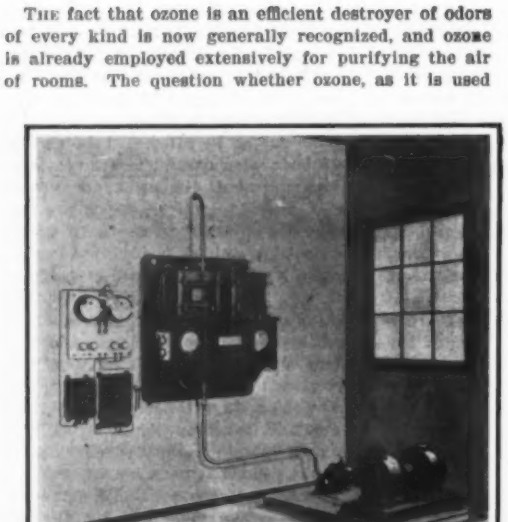


FIG. 2.—OZONE APPARATUS FOR CENTRAL VENTILATION.

FIG. 6.—OZONE APPARATUS IN BRANCH VENTILATING PIPE.

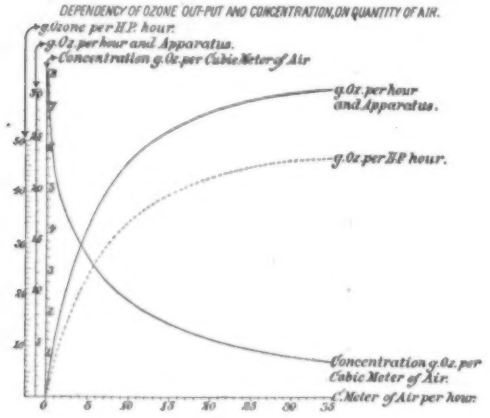

DEPENDENCY OF OZONE OUT-PUT AND CONCENTRATION, ON QUANTITY OF AIR.
g. Ozone per H.P. hour.
g. Oz. per hour and Apparatus.
Concentration g. Oz. per Cubic Meter of Air
g. Oz. per hour and Apparatus.
g. Oz. per H.P. hour.
Concentration g. Oz. per Cubic Meter of Air.
C. Meter of Air per hour.

FIG. 4.

It seems fair to assume, however, that ozone, which possesses so remarkable sterilizing properties when concentrated, is not wholly powerless to destroy atmospheric germs even when it is used in so diluted a form as is customary in ventilating apparatus, provided that the air is somewhat moist and is exposed for a long time to the influence of the ozone. Within the past year the firm of Siemens & Halske of Berlin has put on the market a number of devices for purifying air by means of ozone, some of which were shown in operation at the fourteenth international hygienic congress at Berlin. Some of the devices are described below.

The apparatus illustrated in Figs. 1, 2, and 3 is designed for use in connection with large central ventilating systems. Both types of apparatus have air compressors and the ozone is generated by electrical discharges in cylinders of glass and aluminium. The apparatus shown in Fig. 1 has ten glass cylinders, while that shown in Figs. 2 and 3 has eight cylinders of aluminium surrounded by larger cylinders of glass. Both forms are operated by an alternating current, obtained from a direct current with the aid of a rotary converter, as illustrated, or taken from an alternating current circuit. One pole of the ozone generator is grounded and the wire which connects the other pole with the transformer is insulated and made inaccessible, so that the apparatus may be handled without danger at all times. These ozone generators have high efficiency, as is shown by the curves of Fig. 4. As in other electric generators of ozone, the quantity of ozone formed is a function of the current density and the quantity of air which is forced through the apparatus. The consumption of energy is small, being only 0.75 kilowatt in the small model (Fig. 1) and 2 kilowatts in the large model (Figs. 2 and 3). As only a very small proportion of ozone is required for the purification of air—from 0.05 to 0.5 milligramme (0.008 to 0.08 grain) of ozone to a cubic meter (35.3 cubic feet), according to recent experiments—this apparatus is capable of ozonizing 200,000 cubic meters (about 7,060,000 cubic feet) of air per hour.

In cases where it is desired to ozonize only a portion of the air current, used for the ventilation of certain rooms, it is advisable and quite practicable to insert the ozone generators in the branch air pipes. A simple apparatus for this purpose is illustrated in Figs. 5 and 6. It consists of a number of air-cooled ozone generating cells with plate electrodes, and a "step up" transformer. The entire apparatus is

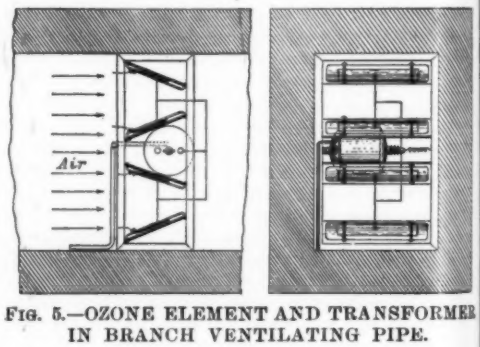


FIG. 5.—OZONE ELEMENT AND TRANSFORMER IN BRANCH VENTILATING PIPE.

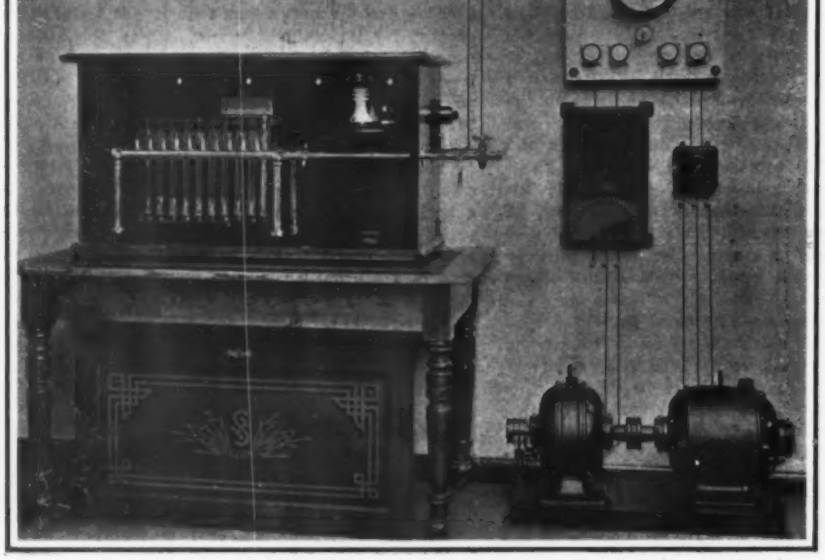


FIG. 1.—SIEMENS OZONIZING APPARATUS WITH TEN GLASS GENERATING CELLS, AND ROTARY CONVERTER, FOR CENTRAL VENTILATING SYSTEM.

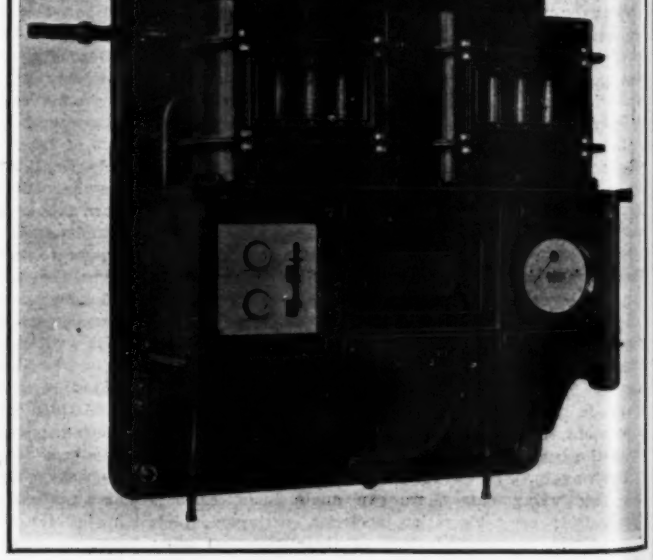


FIG. 3.—WALL APPARATUS INCLUDING TWO OZONIZERS, SWITCHES, GALVANOMETERS, AND TRANSFORMER.

mounted on a frame in the air pipe, with the concavities of the inner electrodes facing the current.

Fig. 7 illustrates other types of ozone elements designed for use in ventilating shafts. All have metallic electrodes, one of which is surrounded by glass or some other solid dielectric, and are so constructed that the air circulates freely through them, as stagnation of air would cause overheating and diminish the production of ozone. The electrodes are of various forms. Type *a* has a plate perforated with smooth

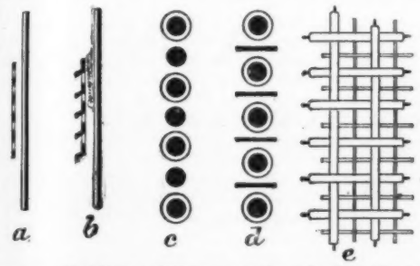


FIG. 7.—VARIOUS TYPES OF ELECTRODES OF OZONE ELEMENTS.

holes, in *b* the edges of the perforations are raised, in *c* the bare and covered electrodes form two interlocking gratings of round bars, in *d* flat bare electrodes alternate with round covered electrodes, and in *e* both electrodes have the form of nets or gratings. Fig. 8 shows the appearance of the completed apparatus, type *d*.

The number of ozone elements required is determined by the volume of air and its degree of impurity. The normal types of Siemens ozonizers are made for currents of from 2,000 to 8,000 cubic meters (71,000 to 282,000 cubic feet) of air per minute and require a power of from 100 to 400 watts. The cost of operation is therefore very small.

For rooms ventilated not by a direct blast of air but by windows, with or without fans, opening upon simple air shafts or the outside of the building, the apparatus shown in Fig. 9 is designed. This apparatus, which is called an "ozone ventilator," contains a number of ozone elements so arranged that they are traversed by part of the entering air current and are sufficiently cooled by the remainder of the current, which passes over their tops. These ozone ventilators may be built into the wall or stand detached. For use in hospitals there is a portable ozonizer, which is inclosed in a frame mounted on rollers, so that it can be moved from room to room (Fig. 10).

An ozonizing apparatus differing from any of the above and still in the experimental stage is illustrated in Fig. 11. This apparatus, which may be attached to the ceiling or wall, contains a number of flat ozone elements of the ordinary type, in which ozone is generated by bluish discharges from a high potential circuit and above or behind these elements a number of metal gratings charged to the same high potential, but placed so far apart that there is no perceptible discharge or production of ozone, but only the precipitation of dust and smoke which is characteristic of statically charged metallic surfaces. This property is strikingly demonstrated by the simple experiment illustrated by Fig. 12. A glass jar about 20 inches high and 4 inches in diameter, into which are inserted two broad strips of moderately fine wire netting, is filled with a dense cloud of tobacco smoke, and the strips of netting are connected with the poles of a transformer, induction coil or influence machine. A violent disturbance, of cyclonic character, is set up in the smoke-laden air, and the smoke vanishes in a few seconds. Dust diffused through the air in the jar is precipitated in the same manner.

The various types of apparatus described in this article are capable of the widest application in purifying the air of theaters, restaurants, factories, markets, and slaughter houses, tunnels, subways, barracks, prisons, churches, lodging houses, and the cabins and holds of vessels. They possess the special advantage that the supply of ozone can be regulated to suit the demand with the greatest ease, either by varying the potential of the electric current or by employing a larger or smaller number of generating cells.

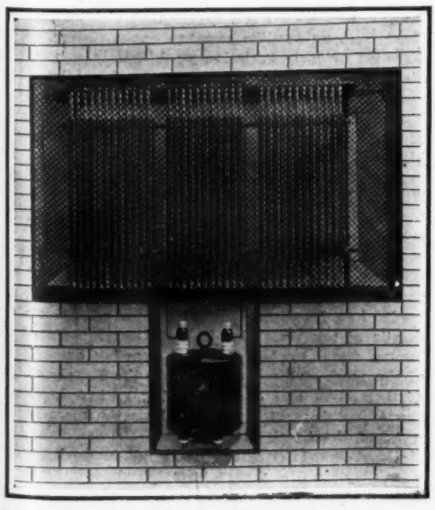


FIG. 8.—OZONE APPARATUS WITH ROD AND PLATE ELECTRODES IN THE SHAFT.

MAN'S PLACE IN NATURE.*

By Prof. HENRY EDWARD CRAMPTON.

WE must now state distinctly and fairly the present views of science regarding man's place in nature. Surely human evolution is a subject that falls within the scope of zoological investigation, unless indeed it can be shown that the human species is exempt from the control of those laws of nature that hold sway over the animate world elsewhere, unless something can be found which excludes man from the animal kingdom. Notwithstanding the most prolonged search not only by zoologists but as well by those who have been unfriendly to the doctrine of descent, the study of man and of men has revealed nothing essentially unique. What is known of the anatomy, development and fossil relations of man is summarized in the statement that he belongs to the genus and species *Homo sapiens*, placed with the apes and some other forms in the order primates because of agreement in certain peculiar details. The primates agree with the carnivora, rodents, and many other orders in the characteristics of the class mammalia, which in turn is only a branch of the limb vertebrata or chordata, which also bears the avaian, reptilian, amphibian and fish branches. And all the vertebrates including man agree with the varied groups of invetebrates in their cellular constitution and in the similar protoplasmic basis of life. As in these structural respects, so in physiological activities and in environmental relations the human species proves more surely with increased knowledge to be only one of the terms in the extensive series of animals. Indeed, the scientific monism of Haeckel and Clifford ventures to assert that man and all other living creatures are one with the mind-stuff of the inorganic world—and this, I believe, is only the logical extension of the genetic and mechanistic hypotheses. However this may be, science holds that human structure is animal structure, and that human lives are biological phenomena.

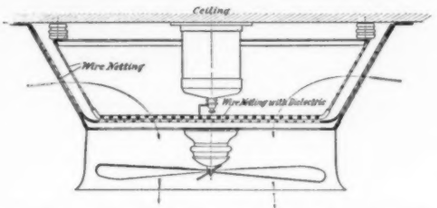


FIG. 11.—CEILING OZONIZER WITH DUST-CATCHING ELECTRODES.

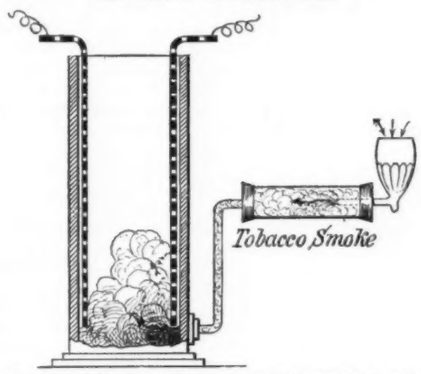


FIG. 12.—ELECTRICAL PRECIPITATION OF SMOKE.

Man is structurally inferior in many respects to some of his zoological relatives—he is a degenerate, indeed, in many parts of the alimentary, muscular and skeletal systems—yet he finds in the higher development of his nervous system an advantage that offsets the weaknesses of his constitution elsewhere. He holds his supreme place by virtue only of superior and more effective control of his organization.

Behind their seeming structural differences, only one real distinction can be found to separate man from the apes—the higher development of the brain. The erect posture, the correlated modifications of skeletal and muscular structures, and apparently the powers of speech and reason, seem to be dependent upon the enlargement of this organ, which, so to speak, has pushed the face around under the brain-case. Therefore he who would be *ο ανθρωπος*—he who looks ahead—must needs stand erect in order to prevent his eyes from looking straight into the ground. But the most careful analysis has so far failed to detect any essential differences in either structural or functional respects between the human brain and the corresponding organs of the higher apes. In brief, then, differences in degree and not in kind or category seem to distinguish man from the apes—as far as science goes.

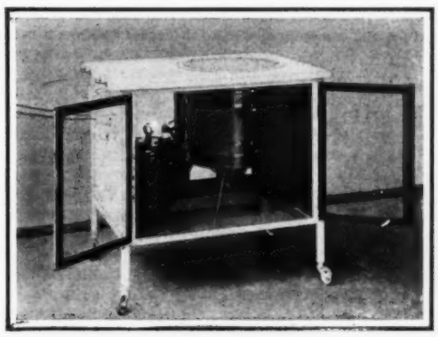


FIG. 10.—PORTABLE OZONIZER FOR HOSPITALS, ETC.

Moreover, the human body is a veritable museum of rare and interesting relics of antiquity—the useless vestiges and rudiments of structures that are more developed in other animals. The complete coat of hair of the embryo, the disappearing thirteenth rib, the ape-like and transitory clasping muscle of the newborn infant's hand, the curvature of the lower limb and the hand-like foot of the embryo, these and scores of other characters are mutely eloquent witnesses to the past history of change that has brought man to his present place in nature. Embryology gives a vast amount of additional independent testimony. For like all embryo mammals and birds and reptiles, the human embryo possesses gill-slits, and fish-like heart and brain. Above all it begins life as a single cell. Zoology asks: What can these things mean, if they do *not* mean evolution and a common ancestry with other forms? The objection that no one has ever seen a one-celled organism evolve into a many-celled one, or into a fish or an ape, or into a man, the zoologist answers by placing upon the table the evidence that a single cell, the human egg, actually does compass the whole history in becoming the almost inconceivably complex adult organism. The process *can* take place for it *does* take place. Paleontology also presents evidence relating to the history of our species, as the third support of the tripod upon which rests the doctrine of human evolution. While opinions differ with respect to the remains of man taken from the many caves and mounds of Europe and America, there is but one generally accepted view regarding the ape-man *Pithecanthropus* of the Javan rocks. The remains of this animal prove among other things that its brain was intermediate between the average ape brain and the average human brain, that the animal was indeed an ape-man and nothing else.

Science holds furthermore that natural factors alone have brought about human evolution. While it is true that the explanation is no more complete for this spe-

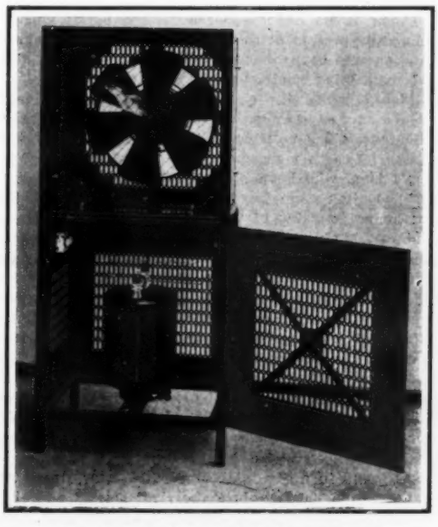


FIG. 9.—OZONE VENTILATOR FOR WINDOWS.

*Abstract of lecture on Zoology delivered at Columbia University in the Series on Science, Philosophy and Art.

cial instance than it is for animals in general, yet the human species is not exempt from the control of the known factors, like those which cause variation or govern inheritance. Indeed some of the significant facts of heredity have been first made out in the human species. Can we doubt the reality of selection and the struggle for existence when scores perish annually in the conflict with extreme degrees of temperature and other environmental forces, when as a result of the unceasing combat with bacterial enemies alone the casualties on the human side number in our country more than a hundred thousand annually?

To the zoologist it seems strange that there is so much opposition to the doctrine of human evolution. In truth he finds this to be proportional to misunderstanding of the facts, for when the evidence is produced—Pelion piled on Ossa—any lingering doubts the observer might have are crushed by an irresistible weight of testimony. After all, our kind is but one of the many hundreds of thousands of living species, and viewing the matter from the calm, impersonal standpoint of scientific study, the fact that he is himself a human being does not distort the investigator's vision, for his perspective is corrected and rectified by the instruments of scientific method. He finds no difficulty in accepting human evolution as a scientific fact—that is, true as far as science goes.

PREHISTORIC MAN.—II.*

A REVIEW OF MODERN THEORIES AND DISCOVERIES.

BY W. F. STANLEY, F.G.S., F.R.ANT.SOC.

Concluded from Supplement No. 1701, page 91.

THE period of early man has been attempted to be traced by remains of pottery, which is thought to be more definite than that of the early chipped flints. In 1851-4 ninety-six shafts were sunk in the Nile mud, at equal distances apart, within a surface of eight square miles, in the vicinity of a statue of Rameses II, at Memphis. At 39 feet in depth in one shaft, a piece of red baked potsherd was found. It is estimated that since this statue was erected, in about 1361 B. C., a stratum of 9 feet 4 inches of mud has accumulated around it. From this it is conjectured that if the Nile mud was deposited earlier at the same rate as it is at present, the potsherd would be about 13,500 years old. Many other pieces were found in different styles of early work at a less depth. The difficulty in making a true estimate of time is the uncertainty that all the conditions of formation of mud were the same formerly as at present. I have not considered the presumed evidence of early advanced art work, of which it is said we have many specimens. One of these that has become very popular with geologists is the portrait of a mammoth engraved upon a mammoth fossil bone. I have examined this and others. In my humble opinion this engraving is quite inconsistent with the rough style of work upon flint implements, which are said to be contemporary with it. There is no doubt whatever that it is a piece of fossil mammoth tusk, which is common enough; but from the knowledge I possess of tools and work I feel sure that this celebrated specimen was engraved by a skilled hand with a good steel graver. My estimate is that it is less than one hundred years old. To assume that it could be engraved by a chip of flint appears to me folly. I may say further that I think that in the research for evidence of early man we are very open to be deceived. Some years ago a clever workman, known as "Flint Jack," was most successful in imitating early flint implements, which were so near the originals as to impose upon many of our enthusiastic amateurs. This does not, of course, infer that we have not a great many genuine specimens of paleolithic work. We have now considered man in relation to prehistoric work; we will now consider evidence derived from the remains of his bones. It is at best only accidentally that the remains of any animal are found. If the animal is left upon the surface of the ground after death, he perishes by disintegration in the atmosphere, or is consumed by some form of insect life. If a beast of prey drags a body (man or other) into a cave, he consumes the flesh and crushes up the bones for the nutriment they contain. With regard to man, if we find the bones perfect, burial must be generally presumed; so that it is only in the remnants and gnawed bones that we feel generally any certainty of man being contemporary with the early animals which occupied the caves. If we except such accidents as I have mentioned, of the crushed man of Mentone, other possible instances are the closing of caves by earth movements, or by the enemies of the cave man, who have blocked him in with stones. I will mention some few interesting cases of the finding of human remains of the early period. The greatest interest is always taken in finding bones of the head, as in this the human species is most prominently distinct. In our own country, as early as 1829, several skulls were found at a depth of 40 feet, at St. Austell, in Cornwall, in an estuary deposit. From the circumstance of earth movements the age of them could not be defined. At Carnon, near Falmouth, at a depth of fifty-three feet, two skulls were found buried in the river mud; these were of the paleolithic type. In both cases some flint instruments were found near. One of the most celebrated skulls, from its being the most carefully investigated by savants, is a skull which was found in a cave at Neanderthal, near Dusseldorf. The cave is 100 feet above the river Dussel, and about the same distance from the top of the rock. The whole skeleton was buried in the cave, but the miners who discovered it in their work of excavating stone, scattered the smaller bones before the arrival of Dr. Fuhlrott on the spot, from whom we have the particulars. The bones remaining were of extraordinary thickness, as were also those of the skull, denoting a man of most powerful frame. The size of the brain was of about three-fourths that of the average European, but its form more nearly approached that of the higher apes. A similar skull to that of Neanderthal was found in a cave at Engis, in Belgium, but this was of slightly higher type. A peculiarity in early jawbones that have been found is that our wisdom teeth, which are valueless to us and often a great source of trouble, were in early man of great value to masticate his hard, coarse food. We did not then grind our corn to make our bread. I will now briefly state what modern biologists suggest as the probable evolution of mankind. I stated early in this lecture the evidence of a constant rise in brain power throughout geological time. When we arrive at the Eocene period, estimated as not less than half a million years ago, we find mammalian life had advanced in its highest point to the stage represented by the presence of the primates, our own order, in the monkey, of which the highest form, until recently discovered, was a gorilla-like ape. It is from one of these ape-like creatures, it is suggested, that man was slowly evolved, through slight variations. The remains of this man-animal have not been found, so that, at present, it is termed "the missing link." Biologists, however, have made many advances in late years, both in finding the remains of man of lower type than any of the known savages living at the present time, and in finding the remains of higher apes than at present existing; the nearest living specimen to man perhaps being the gorilla (*Gorilla gina*). This animal has every bone and every muscle that man possesses, but the proportional sizes of the bones vary considerably between the man and the ape, particularly in that in the ape the arms are long and the legs are short. The brain of the ape is also small—but half the size of the Hottentot's. In the infant stage, when our babies have legs and arms of the same length, and the higher apes nearly so, there is greater general resemblance. The child develops longer legs in walking on flat ground. The gorilla develops his arms in climbing the trees which form his home. This increase of the limb in greatest use possibly progresses from generation to generation, of which I will endeavor to give further evidence presently. Independently of man's great superiority in intellect, and his gift of speech, none of the apes can be said to be man-like. The gorilla comes nearest to man in the structure of his feet and hands, the chimpanzee in the form of the skull, the orang in brain development, the gibbon in the form of the chest. None of these is assumed to be like the ancestors of man. They are possibly the scattered survivors of an ancient branch of the primates, known as the Catarrhine apes, from which the human race appears, according to paleontological evidence, to have been developed in time by consecutive small variations in a man-like direction. The nearest approach of the ape to the man that has been found in a fossil state in recent times is the remains of a man-like ape discovered by Eugene Dubois in Java in 1892. I do not like to trouble you with long scientific names, but I will this time. This highly-organized animal has been named the *Pithecanthropus erectus*. The important parts of the skeleton discovered are the roof of the skull, part of the lower jaw, and a femur. This "missing link," whose age probably dates back to the Eocene period, was found buried under ashes that had fallen from an extinct volcano, which had, at the time of the eruption, probably killed the animal and afterward preserved his bones. There was a great discussion among our most learned naturalists at the time of the discovery, as to whether the animal should be called a man or an ape. Models of the skull were sent to all our important zoological societies, and there was a meeting in congress at Leyden, Cambridge, and Berlin. The subject was thoroughly discussed, and it was finally decided, on anatomical grounds, that it was an ape. The skull capacity, which appears to have greatly influenced the decision, was not much over half that of a very low human race. The connection of the skull with the vertebral column also varied slightly from man. The skull was, in proportional height, intermediate between the Neanderthal skull and that of the chimpanzee. In stature and general form this creature possibly somewhat resembled the Hottentot. To return to the early historical period. This has been set back and verified in a high degree by the recent discoveries in Abydos, by Dr. Flinders Petrie, by his finding tombs of the seven early kings of Egypt, before Menes. The period of the earliest of these kings is certain to be nearly 7,000 years ago. A great number of weapons and tools were found in and near the tombs in chipped flint of high-class workmanship, some rude carvings in ivory, much hand-formed pottery, and a few bronze implements, which last indicate the early Bronze Age. I have here a mirror of about this early period, which has been beaten out of native copper. It contains crystals of silica, which shows that it has never been melted. The handle is of fossil bone. I made an attempt to repolish this mirror in the ordinary manner, to discover its reflecting power, but the surface could not be cut, except by emery, from the presence of the silica crystals. I have also a flint knife of the same period, and a spear-head, the workmanship of which is very perfect. The edge is chipped to fine sharp points, which are only one-fiftieth of an inch apart. This specimen of refined flint chipping represents a lost art. What is most interesting to observe in Dr. Flinders Petrie's discoveries was that the early kings, 7,000 years ago, possessed the art of writing in hieroglyphics, so that their names are recorded. The first historical name we possess at present is that of a king, Ka; the second, Ro; then follow Zeser, Narmer, and Sma. The early kings did not indulge in the long names so common in the following dynasties of Egypt. I have not in this lecture made any consideration of a scientific research in embryology, which is the most important factor of evolution, wherein every animal passes from its elementary stage through the degrees of its ancient evolutional life until it reaches the present actual life existence in the world. This subject being so large it would demand the entire time of a lecture, and could not be made in any way a light, popular subject. Many years ago, when I was a student in evolution, a thought suggested itself to me that if man were derived from an ape-like creature, some vestiges in the direction of early variation would surely exist within historical times. As, for instance, as I mentioned, the ape has longer arms than legs in proportion to the human body. The query is, therefore, have the arms of mankind become shorter and the legs longer in historical time? I collected what data I could and read a paper on "The Variation of Man Within the Historical Period" before the Croydon Natural History Society, over twenty years ago. I followed this subject in research upon several points. I came to the conclusion that certain variations among the most civilized nations were certainly observable, which, I presume, have reference to prehistoric time, that proceeded in a like direction. I can now only give a few details of my research. The earliest records of the human form, by fairly correct drawing or sculpture of the most civilized nations, are the Egyptian, both of themselves and of surrounding nations, and then the Abyssinian, after which follows the more perfect work of the Greek artists. The Egyptian and Abyssinian depicted forms are nearly all in profile. They were possibly first drawn from the shadow. It is for this reason possibly we find very correct and recognizable profile types of the Arab, Jew, and Negro; but, in these drawings, the eyes are placed flat on the

* A lecture given at the Stanley Athenæum.

profile and out of perspective; on the other hand, the ears are correctly drawn, being possibly traced round an amputated ear. The notes I have made are principally on original works, and copies in the British Museum and the Crystal Palace. In the latter buildings we had formerly possibly the finest collection in the world of models taken directly from the antique. In these models of earlier humanity, in relation to the modern European, we may observe that the head in the Egyptian, Arabian, and Persian figures drawn in relief upon the walls of tombs, as at Memnon, Thebes, B. C. 1200, of which we have a model of part at the Crystal Palace, we find the foreheads all very low; the ear is much more forward than its modern position; the face angle is also lower than in the modern civilized man, and it is well known that this angle has increased within quite recent times; but as this angle depends partly on the projection of the jaws, it should rather be taken in relation to the vertical than that of the facial angle, as a mark of progressive development. In skulls of Egyptian mummies the internal capacity is a mean of about 52 cubic inches, and a small internal capacity holds, in antique skulls generally, wherever found. In modern European skulls the brain measures about 66 cubic inches. There are, however, variations in this particular, both ancient and modern, so that we can only estimate from the mean, which indicates with certainty a much smaller capacity in ancient skulls. In the ancient skulls generally there is greater development in the jaws, the cheekbone projects more, the teeth generally project more, the chin less, and the lower jaw is wider and stronger. The Sphinx, in Egypt, represents possibly the earliest form of head we possess.

We have now greater entire stature. This matter is somewhat difficult to follow with certainty, as the scale to which the human figure is represented in paintings and sculpture varies, being often much exaggerated for the figures of important persons. We have, however, on this subject, the important evidence of the bodies of great men and women preserved as mummies, and as it is the rule that the aristocracy of any nation are the tallest and finest human forms, we may assume this rule always held. Thus, in the British Museum we have twenty-five mummies exhibited of important persons, which I have measured as carefully as I could, allowing for wrappings. The average height of the bodies are: males, 61 inches; females, 55 inches. The mummy of the celebrated Cleopatra measures 54 inches; the body is represented on the lid of the coffin, about 4 feet 4 inches, which was possibly her true height, the feet being extended as far as possible. This is about the average height of an English girl of 11. In some very ancient mummies' coffins recently found in the third Pyramid, about 3,000 B. C., a King Menkaura measured 52 inches, a king of sixth period measured 56 inches. That the Egyptian of the dynastic period depicted was of average height to surrounding nations may be inferred by sepulchral paintings, where the Egyptian, Negro, Jew, and other nations are represented of about equal height, as seen in the painting over the doorway in the Egyptian room of the British Museum. The same may be observed in the Abyssinian monuments, where Egyptians and other nations are represented of about equal height. By inference, the average civilized man has increased in height not less than 5 inches within 4,000 years.

The arm, in all antique works, appears longer in proportion than in the modern figure. The cause of this is generally that the legs have increased in length, more particularly the thigh-bone. The short thigh-bones are very evident in all Egyptian statues. The cast of Amnothph III (B. C. 1260) in the Crystal Palace shows this in a marked degree in the excellent bas-reliefs of Sennacherib's palace (B. C. 800); in the British Museum, the arms of the figures approach nearly the length of the legs. This proportion in diminishing ratio is found to hold in Grecian works as well as with Abyssinian. Thus, in the Apollo Belvedere, which has been considered the most perfect form, the arm exceeds by nearly the length of the hand the proportions of the modern human figure given by Marshall, who is taken as the highest authority by artists. That this is a progressive variation is indicated in that the child at birth has arms and legs of equal length, the same as many of the apes.

The hands were formerly proportionally larger and, if we may infer from Egyptian sculptures, flatter, the thumb being less opposable; the little finger was also larger and longer. In many of the Egyptian figures the fingers are nearly of one length. In a skeleton mummy hand in the British Museum the second and third fingers measure about 3¾ inches, the forefinger and little finger, which are of about equal length, 3¼ inches, as nearly as I could measure through the glass case.

The feet were formerly generally longer and flatter, the big toe never being the longest in the early works, and scarcely above the others in size. This is no doubt partly due to the pressure in boots; but the development of the great-toe has possibly been constant and due to walking in an erect attitude. The modern toes are little over half the average length of the fingers. In Egyptian figures the toes approach more nearly the length of the fingers, as in the Quadrumana. In the statue of Rameses II, which is in the best style of Egyptian art, the second or longest toe measures 2¼ inches, the longest finger measures 2¾ inches. It is possible that the great-toe, of which we have now lost the use, was at one period opposable in a certain degree as the thumb is, as we find, in Egyptian monuments, mechanics holding wood, leather, etc., between the first and second toes; for instance, a currier dressing one end of a strap with his two hands, which is held by his toes at the other end. The Japanese and some Indians appear to have retained the use of the toes. Mechanical trades, at which it is now customary to work in a standing attitude, were formerly worked at in a sitting, squatting, or kneeling attitude, such as carpenters, cabinetmakers, masons, ropemakers, etc., as we find these trades depicted on the walls in Thebes; so that we may assume that when the foot was more handlike, and the leg more armlike, the foot could be used as a hand, and the leg and foot were less developed for standing and walking, and that the sitting position was less fatiguing, particularly as a working position. Progressive development appears to have so far differentiated these members in our higher types that the hand has become perfect for work only, and the foot and leg have been developed for walking and standing only. The separate toes in highly-civilized races are now useless, and will possibly in time be absorbed. In defect of hands from birth it has been found that the toes, with early training, will fulfill many of the functions of the hand, as in writing, drawing, etc. This points out that, although the toes in ordinary life have become obsolete to use as hands, their former function could be reclaimed if required.

We may infer from early writers, Aristotle and others, that infants were very frequently born covered with hair. I think we may accept the narrative of Jacob and Esau as indicating this as a common occurrence at the time that this narrative was written, as the circumstance is mentioned without comment as being anything remarkable. The state of hairiness of Esau is very clearly defined in that Rebekah put the skin of a kid upon Jacob's hands and upon the smooth of his neck to deceive Isaac, and we are told the device answered perfectly. Very few races, even of savages, retain hair over the body at the present time, and no race possesses it in the animal-like form of the kid here inferred. The Aninos, of Japan, only have hair over the body. The absence of hair no doubt depends largely upon the effects of clothing. I may now recapitulate that the whole tendency of geological, biological, and other evidences, of which I have given a sketch as far as time permits, shows that early man in Europe, and of the whole world as far as known, was at an early period of a very low type. Geological evidence points that the changes by progressive variations have been very slow, so that this period in Europe extends between 20,000 and 50,000 years into the past. There is no doubt that at the earliest period there were different degrees of higher and lower races of man; that the higher races constantly conquered and exterminated the lower, just as we do at the present time in our colonies; so that, from this reason alone, there must have been a constant advance in human organization. Even in our earliest historical time, what we at present understand as "humanity" had no existence. We can in many instances refer back to a period when the ruling monarch, if he could gain power over the people, used his power entirely for brutal and selfish purposes, and made his people slaves, whom he commonly kept in superstitious terror through his priestcraft. The king tortured his captives taken in war to cruel death, or at least made them his slaves, or sold them. The young women he often took for concubines, with entire negation of all previous human rights, while his slaves built his palaces and harems. It is only very slowly that our race has advanced to attain any of the rights of social humanity.

CARBON MONOXIDE AND THE TOXICITY OF TOBACCO SMOKE.

IF a mere mouthful of tobacco smoke be blown upon a dilute solution of blood a pink coloration at once appears which is characteristic of the compound formed when carbon monoxide unites with hæmoglobin and spoils its healthy function. The proportion of carbon monoxide in tobacco smoke is considerable, and it is a question whether nicotine can be held to be responsible at all for the symptoms summed up in the words "tobacco-smoke poisoning." At all events, it is well known that though nicotine exists in tobacco yet a very small proportion of it appears in the tobacco smoke. Undoubtedly there are poisonous oils present, chief of which is pyridin. Pyridin apart, however, it is certain that one of the abundant products of combustion (or rather of incomplete combustion which the production of smoke implies) is the poisonous gas carbon monoxide. It has been calculated in practical experiments that one ounce of tobacco when smoked in the form of cigarettes gives as much as from one pint to four pints of carbon monoxide gas, while the same amount of tobacco smoked in a pipe gives from two and a quarter to five pints of the gas. So far it would appear that the pipe ought to be more pernicious than the cigarette if it were not for the fact that it is practically only with the cigarette that inhalation of the smoke is indulged in. The symptoms of carbon monoxide poisoning resemble in a noteworthy manner the symptoms of tobacco-smoke poisoning. The excessive smoker often develops, for example, a tendency to dizziness and shortness of breath on exertion; there are evidences also of heart disturbance, and he is troubled often enough with palpitation, or, at least, a consciousness of the heart's beating, and the senses, power of judgment and of movement are frequently impaired. In some respects the symptoms of carbon monoxide poisoning resemble those produced by an immoderate or chronic indulgence in alcohol. There can be little doubt, therefore, that the association of smoke and drink is a poisonous one, both conspiring to bring about similar toxic effects. When we consider the quite large amount of carbon monoxide present in tobacco smoke, and compare with this fact that as little as 0.17 per cent of the gas in the air is fatal to animals, though usually 0.4 per cent is required, and that anything above 0.15 per cent is regarded as distinctly dangerous, it is obviously within the bounds of probability that tobacco smoke can be very harmful on account merely of this gaseous constituent. If this is so, what a serious complexion does the habit of inhaling tobacco smoke assume, in which procedure the smoke and the carbon monoxide contained in it are introduced directly into the circulatory system. These facts call forth also an interesting reflection on the headache and drowsy and stupid feelings of the person who has been shut up in a "smoker" on the railway train or in the badly-ventilated atmosphere of the smoking-concert room.—Lancet.

NEW TANNING PROCESS.

MESSRS. LOUIS MEUNIER and A. Seyewitz, of Paris, have brought out a new tanning process which is of some interest. Briefly stated, it is as follows: If skins from which the hair is removed are submitted to the action of a hydroquinone solution in a closed vessel and out of contact with the oxygen of the air, it is found that the skin does not change its appearance and that it is always affected by boiling water. In this case the tanning action does not take place and the fiber does not become insoluble. But if we recommence the same experiment in contact with air and in presence of an alkali in order to facilitate the oxidation of the hydroquinone, we find that the skin fiber is colored successively in pink, violet, and brown. When the fiber has reached the brown color, it is quite insoluble and will resist the action of boiling water. The tanning which is thus produced in contact with air is carried out more favorably when the conditions are such that oxygen is absorbed, and to this end various substances can be added to the bath. Another experiment shows that instead of making the fiber insoluble by the slow process in which we use the oxidation products of hydroquinone which are gradually formed upon contact with the air, we can submit the fiber directly to the action of other bodies such as quinhydrone or quinone, these being products which are obtained by the action of different oxidizing agents upon hydroquinone. We then observe that the skin passes in turn through the different colors mentioned above, pink, violet, and brown. When the skin has undergone in a uniform way and throughout its thickness the action of a quinone bath containing only one per cent of the skin's weight in quinone, the fiber becomes insoluble and is transformed into a leather whose resistance to the action of water, acids, and alkalies is superior to that of all the known leathers, even chrome leather. The action of the quinone on the fiber is very rapid if the skin shows an alkaline reaction. It is slower and may cease entirely if the skin has an acid reaction. If we exhaust the used bath by ether, we can extract a good quantity of hydroquinone, and this shows that a part of the quinone has been reduced by the fiber to the state of hydroquinone. The fiber has thus undergone an oxidation at the same time that it is made insoluble. The skins which have been tanned by quinone have a great affinity for acid and basic coloring matters. Dyeing with alizarine color as well as with wood colors can also be easily carried out.

The committee of the Röntgen Society, which has under consideration the establishment of a standard unit of radio-activity, has made an interim report in which it recommends that one milligramme of pure radium bromide be regarded as the standard, and that the ionization produced by the γ rays from it, after passing through one centimeter of lead, be taken as a measure of the unit of radio-activity. There are, however, certain difficulties in the adoption of these suggestions which the committee has still under consideration, and will deal with in a future report.

THE RELATIONAL LIFE OF PROTOZOA

THE CAREER OF A SIMPLE ORGANISM.

BY E. FAURE-FRÉMIET.

We find in microscopic organisms a complexity of phenomena and a multiplicity of needs as great as those which characterize higher animals. The free and nomadic existence of micro-organisms, their remarkable agility, prodigious physiological activity, incessant quest of food, extreme delicacy and incomparable sensibility, make up a life of great complexity. The higher animal, or metazoon, is fitted for the performance of the diversified actions conditioned by its environment by the possession of sense-organs, nerves which indirectly connect those organs with muscles and other active organs, and in many cases a higher nerve center. In a word, it possesses the means of effecting the most varied associations of external stimuli and the reactions which they call forth. These reactions comprise tropisms, reflexes, and intelligent acts. But the Protozoon is only a simple cell, a microscopic bit of protoplasm containing a nucleus, capable of independent existence but organized only to a very limited degree. Hence, the study of the relational life of Protozoa is of especial interest, because it borders on the intimate functional activity of living matter.

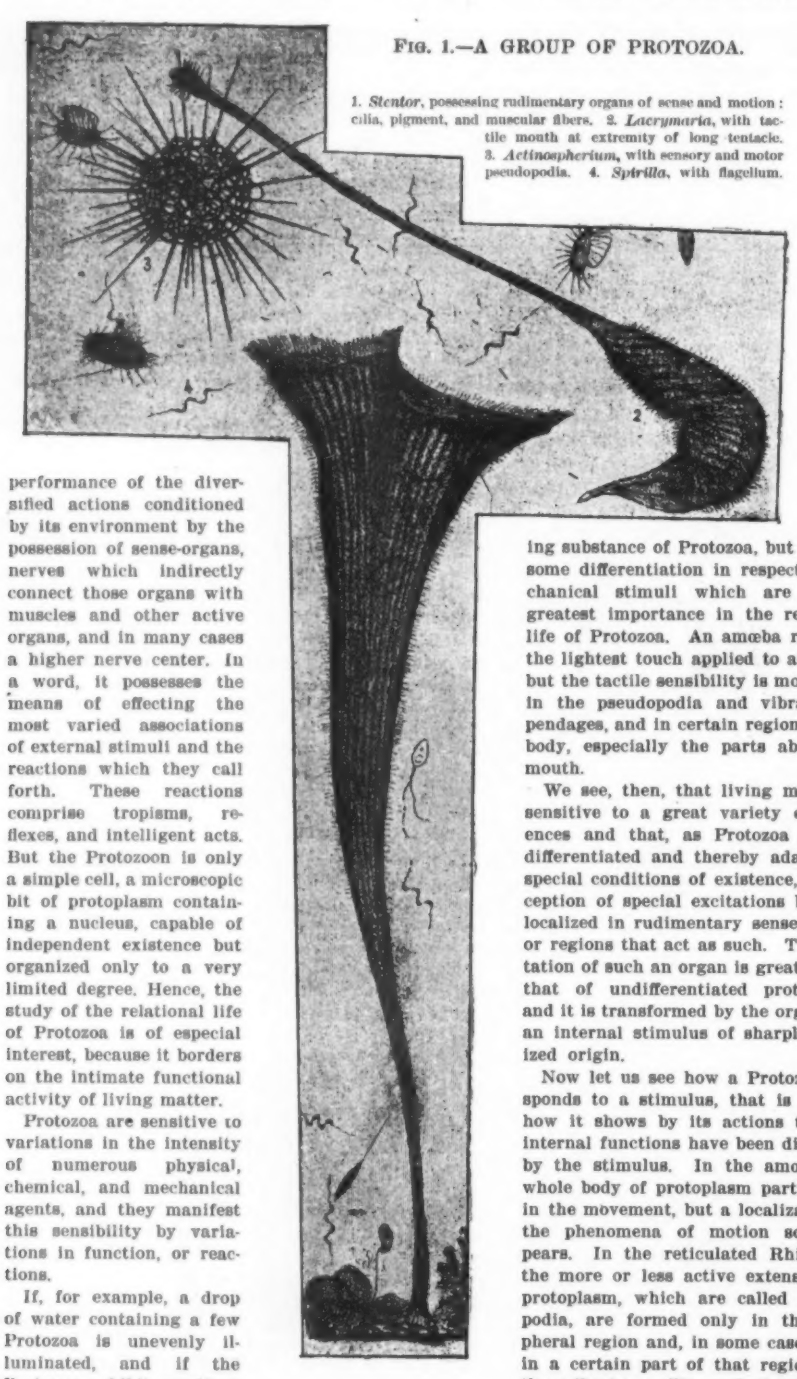


FIG. 1.—A GROUP OF PROTOZOA.

1. *Stentor*, possessing rudimentary organs of sense and motion: cilia, pigment, and muscular fibers. 2. *Lacrymaria*, with tactile mouth at extremity of long tentacle. 3. *Actinosphærium*, with sensory and motor pseudopodia. 4. *Spirilla*, with flagellum.

Protozoa are sensitive to variations in the intensity of numerous physical, chemical, and mechanical agents, and they manifest this sensibility by variations in function, or reactions.

If, for example, a drop of water containing a few Protozoa is unevenly illuminated, and if the Protozoa exhibit reactions related to the differences of illumination, we are justified in concluding that these Protozoa are sensitive to light and that they have been excited by the variation in illumination.

In general, the entire mass of protoplasm of a Protozoon is sensitive to external influences, but the receptivity of living matter may be greatly augmented by differentiation and the adaptation of certain parts to the reception of special excitations. In Protozoa all those regions where the protoplasm is nearly or quite naked are particularly sensitive to chemical influences. Such regions are the vibratile cilia, the pseudopodia and the parts about the mouth. As a rule light affects protoplasm, not directly, but through the production of chemical changes. The effect may be distributed through the entire mass of protoplasm, but it is usually confined to a sort of specialized organ, represented by a leucite or grain of pigment.

Rhizopods, Peridinia, and some Flagellates possess little masses of protoplasm saturated with a pigment (chlorophyl or diatomine) which evolves oxygen under the influence of light, and many Infusoria have grains of blue, red, or black pigment. In a few Protozoa these elements show a tendency to congregate in certain regions, thus forming a rude organ of light perception which in some species is even provided with a rudimentary lens in the form of a grain of paramylum.

Heat and electricity apparently affect the entire living substance of Protozoa, but there is some differentiation in respect to mechanical stimuli which are of the greatest importance in the relational life of Protozoa. An amœba reacts to the lightest touch applied to any part, but the tactile sensibility is most acute in the pseudopodia and vibratile appendages, and in certain regions of the body, especially the parts about the mouth.

We see, then, that living matter is sensitive to a great variety of influences and that, as Protozoa become differentiated and thereby adapted to special conditions of existence, the reception of special excitations becomes localized in rudimentary sense organs or regions that act as such. The excitation of such an organ is greater than that of undifferentiated protoplasm, and it is transformed by the organ into an internal stimulus of sharply localized origin.

Now let us see how a Protozoon responds to a stimulus, that is to say, how it shows by its actions that its internal functions have been disturbed by the stimulus. In the amœba the whole body of protoplasm participates in the movement, but a localization of the phenomena of motion soon appears. In the reticulated Rhizopods, the more or less active extensions of protoplasm, which are called pseudopodia, are formed only in the peripheral region and, in some cases, only in a certain part of that region, and the vibratory cilia and flagella are special organs which, in some instances, form a very complicated motor apparatus.

FIG. 6.

Urostyla encountering and swallowing *Glaucoma*.

Contractility is one of the most important factors of movement in the Protozoa. This property is often common to the entire body of protoplasm, or rather to its hyaloplasmic warp, but the latter may be localized, differentiated and arranged in contractile fibers or bundles, as in *Stentor* and *Spirostoma*. In some forms of *Vorticella* the differentiation is carried still further, and there are three distinct contractile elements which can act either separately or simultaneously.

The motility of protoplasm is manifested also in certain organs of attack and defense, such as the extensible tentacles of suctorial Infusoria and the trichocysts expelled by certain ciliated Infusoria on contact with a victim.

In short, Protozoa are sensitive to various influences and react to them, and both sensibility and reaction may be localized in particular parts of the body. Hence it is evident that the relational life of the ganism may be very complex. Jennings has sho that the behavior of Protozoa is far more comp than appeared from the experiments of Verworn Loeb with a limited number of physical and chemi stimuli. Let us see if co-ordination plays any part this behavior.

Consider a *Stentor* immersed in an unevenly illu

FIG. 2.—RUDIMENTARY EYES OF PROTOZOA.

1. Pigment spot (*Fabrea*). 2. Pigment and amyloid lens (*Ophryoc* 3. Pigment and crystalline lens (*Gymnodinium*). 4. Transparent grains imbedded in red-pigmented matter (*Euglena*).

inated drop of liquid. This Protozoon is pigmente and sensitive to light, and the inequality of illumina tion brings about changes in the working of its loc motor apparatus, the ultimate result being a retre from the source of light. The *Stentor*, however, is n

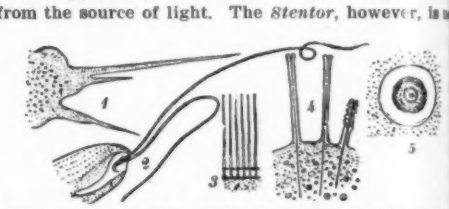


FIG. 3.—TACTILE AND MOTOR ORGANS OF PROTOZOA.

1. Pseudopodia of an Amœba. 2. Flagella of a Flagellate. Cilia of a Infusorium. 4. Rudimentary otoliths of *Loxodes*.

directly repelled by light. It simply responds to th stimulus of light by a variation in its movement which produces a change in its direction of progre sion, and the continued exposure to light causes series of changes in direction until the animal ha

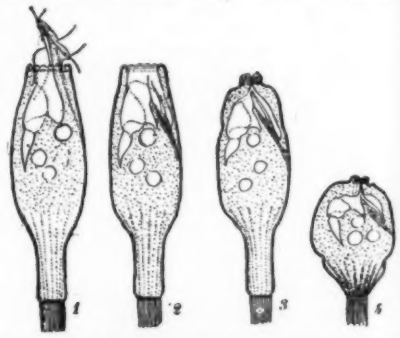


FIG. 4.—SUCCESSIVE STAGES OF REACTION IN OPERCULARIA.

1. Extended. 2. Contraction of longitudinal muscle. 3. Contraction sphincter. 4. Contraction of internal fibers.

pens to reach the dark part of the field. These ha hazard changes of direction are called "essays" b American biologists. Now consider a very simple cil ated Infusorium, such as *Glaucoma*, swimming in homogeneous liquid. The body of this Protozoon

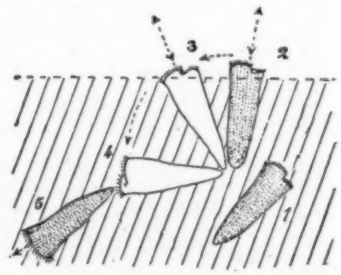


FIG. 5.—"ESSAYS" OF STENTOR TO ESCAPE LIGHT.

rigid and concave on the side on which the mouth situated. It is entirely covered with vibratory cil and the mouth is furnished with a powerful vibrator appendage. The anterior extremity of the body pointed, while the posterior extremity is broad an blunt. Owing to these peculiarities of form, the an

al can move only forward, and in a spiral or circle f large radius. On receiving a suitable stimulus the ovement of the cilia is suddenly arrested and then eversed. The result would be to make the animal ove backward, if it could do so, but as it cannot, the otion is converted into rotation about the center of avity. Consequently, when the normal movement of he cilia is resumed the animal starts off with its ointed end forward, as before, but in a different irection. Here we have an "essay" brought about by ery simple means.

Now let us consider a more highly developed Protoon subjected to more complex conditions, for exmple, a hungry *Urostyla* in the presence of a possible ictim, say a *Glaucoma*. The *Urostyla* is a large Infuorium with a capacious mouth surrounded by a fringe f membrane which is used both in swimming and in eizing food. It also has fifteen rows of vibratory cilia. The body is flexible, somewhat contractile, and of a orm which makes progression with the mouth forward asier than the reverse motion. When a fasting *Urostyla* comes in contact with a smaller Infusoria it experiences a violent excitation which produces an immediate reaction. The motion of the cilia is reversed and the *Urostyla* recoils and swerves to one side. It soon resumes its normal motion, but in a new direction. In consequence of the persistence of the internal excitation this phenomenon is repeated again and again. If one of these "essays" carries the animal far from its prey, the latter escapes, but if a second contact occurs the *Urostyla* stops swimming and executes a series of movements apparently co-ordinated, which result in the swallowing of the prey. The *Urostyla* wraps itself around its victim and the membranes about the mouth work in such a manner as to hasten deglutition. It appears, then, that the behavior of Protozoa may exhibit associated and apparently co-ordinated reactions.

What is the significance of this? We have seen that a Protozoon may have organs of sense perception and organs of reaction. Does it also possess conducting organs, analogous to nerves, and centers of co-ordination? Attentive study of the phenomena answers this question in the negative.

Hence the following conclusion is reached:

The protoplasm of a Protozoon possesses a chemical organization which is characteristic not only of the genus, species, and variety, but also of the individual at the given epoch. This organization is the resultant of all the past states of the animal, of all the causes that have modified its physiological condition. In other words, the protoplasm possesses a "historical structure" of infinite complexity by means of which the excitation received by a special receiving organ is transformed into a reaction. It is easily conceivable that this historical structure, different for each individual and for each instant of its existence, may impress upon the reaction a special character, in harmony with its mode of life. Thus we see, though we cannot yet explain, how the reaction may be adjusted to the excitation so closely as to suggest co-ordination.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

FULGURITES.

A SHORT ACCOUNT OF "LIGHTNING TUBES."

BY H. BERG.

FULGURITES, also called "lightning tubes," are tubular vitreous objects which are formed in the earth by the fusion of quartz sand by strokes of lightning occurring under special conditions. They are seldom found, and consequently are little known. It might be thought that an attentive observer would have little difficulty in discovering fulgurites, in view of their almost imperishable character and the frequency of lightning strokes, but not every discharge of lightning that reaches the earth produces a fulgurite. For the formation of these singular objects peculiar conditions, both of soil and of weather, are required. Above all, the soil must be dry and must contain a large proportion of silica. It is probable that fulgurites were not unknown to the ancients, and it has been conjectured that the Etruscan lightning conjurors made adroit use of them. The earliest well-attested discovery of a fulgurite, however, was made in the year 1706 by a Silesian pastor, who described it as the product of "subterranean fire." Nearly a century later, in 1805, the discovery of several fulgurites in Westphalia led to a systematic search, in the course of which numerous fulgurites, some of them 18 feet in length, were found in various parts of Germany and in England. Since that time fulgurites have been exhumed in many places and certain localities have yielded numbers of them, thus disproving the old saying that lightning never strikes twice in the same place. In Poland, for example, 26 fulgurites were found in a space of about an acre.

The writer has explored the sites of a great many lightning strokes, but has found only three fulgurites, which are now preserved in the geological museum at

THE NIEHUSEN FULGURITE.

Rostock and are herewith pictured and described. The first was discovered at Niehusen in 1892. It was found broken into many fragments, varying from ½ inch to 3 inches in length, on the surface of a bowl-shaped depression in the sandy soil. When the pieces had been fitted together and strung on horse hair, the reconstructed fulgurite was nearly a yard long. The sand had, therefore, been swept away by the wind to a depth of a yard since the lightning stroke had occurred, and short sections of the tube had broken off as they were exposed. A remnant fixed in the ground

THE LIESSOW FULGURITE.

I. Large tube. *II.* Small tube. *III.* Cross section of large tube.

was also discovered. In all there were nearly 100 fragments, which when properly assembled, produced a forked tube measuring 32 inches in a straight line from end to end. The main tube has an elliptical cross section and is slightly twisted, but the cross section of the right-hand branch is circular. The internal diameter nowhere exceeds ⅛ inch. The inner surface is glossy and gray in color, with dark spots due probably to iron; the outer surface is light, gray and very rough, resembling sandpaper in appearance. At the bottom the main tube turns to the left and ends in a burst bulb, but the right-hand branch terminates in a sharp point.

The second fulgurite was found in 1902, in a fir grove at Liessow. The lightning discharge had passed through several trees, but instead of passing out to the ground through one of the large roots in the usual manner, had sprung from a tree trunk to the ground and formed in the sandy soil two fulgurites which differ greatly in size and form.

In the upper layer of soil, composed chiefly of leaves and moss, only very small and separated slag-like particles were found. The continuous tubes were confined to the subsoil of fine yellow sand. The small tube is a very fragile, thin-walled cylinder, 8 inches long, and 1/5 inch in internal diameter. At a little distance from it was found the large and very beautiful larger fulgurite, which has a length of 4 feet and an internal diameter of about 1 inch. The upper half of it was inclined, lying parallel to the course of a large root, but the lower part was vertical except for slight deviations. Pebbles as large as a hen's egg were found partially imbedded in its glassy wall. The vertical length of the tube was determined by the depth of the layer of sand, about 4 feet. In the clay which underlay the sand the tube was replaced by a crevice of which the cross section was about 5 inches long and very narrow except in the middle. The crevice was lined with a continuous glassy coating. This is the first known instance of fulgurite formation in a clay soil.

On June 26, 1905, a farmer of Krummendorf, near Rostock, saw a flash of lightning which appeared to strike very near him. After the storm he found a scorched potato vine about 800 feet from his post of observation, and in a week every vine within two yards of the scorched one had withered. In September the writer examined the spot and dug up a dozen fragments of a fulgurite 4 feet long and nearly ½ inch in internal diameter. Only particles of slag were found in the surface soil, which was composed largely of stable manure, the continuous tube being formed in the yellow diluvial sand beneath. Here too, as at Liessow, the sand was underlain by clay, through which the path of the discharge was marked by a crevice which, however, extended only a few inches, to the ground-water level of electrical equilibrium. The lower part of the fulgurite showed numerous branches, none of which could be traced for more than an inch because of their small size and fragility. The tubular concretions of a rusty brown color which are formed by the seepage of water through ferruginous soils are sometimes mistaken for fulgurites. The same error is often made in regard to the incrustations which form about roots in calcareous soils.—Translated from Die Gartenlaube for the SCIENTIFIC AMERICAN SUPPLEMENT.

Next to iron, zinc is the metal produced in largest quantity by Germany. She ranks foremost in the

THE KRUMMENDORF FULGURITE.

world's production and her output has increased from year to year. The figures during 1907 even exceeded the home consumption by 24 per cent Zinc plays a great part in Germany's foreign trade, above all in the export trade. The amount exported was more than double that imported. It amounted to 68,907 tons in 1907 of a value of £1,864,450.

THE TORES OF SATURN.

AN EXPLANATION OF A SINGULAR PHENOMENON.

BY PERCIVAL LOWELL.

On June 19, 1907, a new phenomenon disclosed itself in the Saturnian ring-system. On the morning of that day, the planet being so placed at the time as to present its rings almost edgewise to the earth, a curious detail was observed at Flagstaff in the shadow which then banded the planet's equator. This equatorial shading, which was in truth the shadow of the rings upon the ball, seemed almost to belie its function because of the lack of density it offered to the eye. Far from being dark, it was only moderately dusky, and furthermore presented when first looked at a tripartite appearance. On more careful scrutiny, its lack of homogeneity proved to be due to a narrow black line that threaded it medially throughout its length, the black core being perhaps one-fourth as wide as the less dense background upon which it stood. At the same time the rings themselves could with attention be made out as the finest knife-edge of light cutting the blue of space on either side the planet's disk. As the sun was at that moment 32 min. north of the plane of the ring-system, while the earth was 2 deg. 16 min. south of it, the two were on opposite sides of the system, which fact combined with its then visibility shows that the rings are never wholly lost in the Flagstaff glass.

The planet was not looked at again at Flagstaff until October 31, other work occupying the observatory in the meantime. In November, however, it was critically studied. The dusky band was evident as in June and the black line made core to it as before, being plainly perceptible to all the observers. On the 12th and 13th of the month I measured both with the micrometer, the measures on the latter date being the more numerous and exact; for the band was then measured between the threads, outside them, and from center to center of the same, while the thread-like core was estimated in terms of the thread itself. The mean of the measures with the suitable corrections applied gave:

for the whole shadow..... 0.46 sec.
and for its black core..... 0.10 sec.

The band was tinged a faint cherry-red (November 5), rather more strongly so than the planet's own belts which could be seen both north and south of it. The black medial line in the midst of it was by no means even. It both undulated slightly and showed irregularities of outline, one black bead in especial being noticeable about halfway from the planet's center to its (the planet's) eastern limb (November 13, 14h. G.M.T.). The line also seemed not quite central in the belt but a little nearer its northern edge. The sun was now 1 deg. 39.5 min. south of the ring-plane, while the earth was 50 min. north of it. So that both bodies were now again on opposite sides of it, having respectively changed across.

Although seen by all the observers at Flagstaff, the black core was not caught by Barnard at Yerkes, nor has it been reported from the Lick. This, however, is in keeping with the definition at the first place disclosed already by its greater space penetration for stars.

The rings themselves were equally visible, in fact were now easy objects, although, as before, only the edge of their plane was presented to the eye. But, in addition to the general line of their light, agglomerations were plainly discernible on them, attention being directed to that end. The agglomerations were symmetrically placed, two on either side the ball, and continued observation showed them to be permanent in position. Micrometric measures were made upon them by both Mr. Lampland and by me from November 3 to November 9. The most complete were those of the latter date, which, while agreeing in place with the earlier ones, gave not only the center of the agglomerations but their beginning and end in distances from the planet. My measures on that evening, with which those of Mr. Lampland substantially agree, were as follows:

November 9, 1907. —G.M.T. 15h. 25m. to 15h. 50m.

		In Seconds of Arc from the Nearer Limb.	In Equat. Radii of Saturn from the Planet's Center.
RIGHT.			
Mean of			
3 measures.	Inner edge of inner thickening	1.00	1.11
2 measures.	Outer edge of inner thickening	3.94	1.43
2 measures.	Gap (most conspicuously vacant spot)	5.36	1.58
3 measures.	Inner edge of outer thickening	6.92	1.75
4 measures.	Outer edge of outer thickening	8.51	1.92
LEFT.			
2 measures.	Inner edge of inner thickening	1.15	1.12
2 measures.	Outer edge of inner thickening	4.22	1.46
5 measures.	Gap (most conspicuously vacant spot)	5.58	1.60
3 measures.	Inner edge of outer thickening	6.53	1.71
2 measures.	Outer edge of inner thickening	8.46	1.91

At the same time measures of the whole ring gave:

Mean of
2 measures. On the right measured from the nearest limb, reduced to equat. radii from the planet's center 2.164
1 measure. On the left measured from the nearest limb, reduced to equat. radii from the planet's center 2.145
4 measures. From W. to E. end visible double measures, reduced as above 2.191

The equatorial radius, also measured, came out:

Mean of
2 measures .....9.245 sec.

Several things are deducible from these measures. First: It is evident that the rings could not be followed quite to the outer limit of ring A, as that stretches to 2.25 or 2.30 radii from the center of the planet, according to whose measures of the system we adopt, while the measured breadth was now at most 2.19. This implies that the outer part of ring A has less thickness than the rest; for we cannot refer the effect to less breadth of ring there being intersected by the line of sight, since the earth was on the opposite side of the ring-system from the sun. The average width of the thread of light upon which the agglomerations were strung was by comparison with the black core of the shadow not over 80 miles.

Secondly: The present measures indicate that the rings approach the body of the planet closer than they have been measured before.

Thirdly: The measures of the positions of the agglomerations show that Olbers's explanation of them, indorsed by Seeliger, fails to account for the appearances.

Fourthly: These positions point to another explanation of some interest. And

Fifthly: This latter explanation proves also to account for the phenomena of the shadow, and incidentally to answer a query propounded by Seeliger on previous observations of it. To make this clear we will begin by quoting Seeliger upon the observations and deductions on the last occasion when the rings were presented as now edgewise to the earth.

"The ring, according to Mr. Barnard, was completely invisible at the end of October, 1891, even in the most powerful glass of the Lick Observatory. He caught it for the first time on October 30, 1891, 1h. 7m. G.M.T. As Mr. Oudemans could see nothing of the ring on October 29, 17h. 9m. G.M.T., its reappearance falls within the narrow interval between these two dates. At that time the earth had an elevation above the ring of 1 deg. 56 min. Mr. Oudemans further remarked on the same day, 'A fine dark streak* runs across the equator;' and explained this as the projection of the dark ring upon Saturn's disk, because it still remained visible after the sun had risen a little over the plane of the ring. Against this interpretation there is practically nothing to be said; only it may perhaps be remarked that here might well be the work of the bright ring too. For the shadow made by this ring does not lie exactly between two planes, and a part of it could constantly be found in the shadow of the other ring, even after the sun had risen a little over the plane of the ring-system. One has thus the advantage of explaining a somewhat greater breadth of the dark streak; and this is to be welcomed, as the minor part of the crape ring, as above remarked, is almost completely transparent, and therefore lets the disk of Saturn behind it be seen and itself does not appear quite black."

"Before the ring begins to be visible, it must disclose itself as a dark stripe across Saturn's disk. This was a fact seen and drawn by Mr. Barnard. He found on October 22, for the breadth of the dark band 0.6 sec., and for the position of its middle point from the north limb (of the planet) 7.40 sec.; from the south one 6.56 sec. Mr. Barnard asserts that the measured breadth entirely agrees with the ephemeris data. I find, however, for an elevation of 1 deg. 41 min. of the earth above the plane of the ring, its width to be 0.16 sec. or 0.24 sec., according as the bright ring alone is considered or the dark ring is included as well. On the contrary, I find very good agreement between the observations and the data for the position of the dark band of 7.64 sec. and 6.72 sec. from the north and south lines respectively, and of 7.60 and 6.7 sec. if the dark ring be also comprised. The above remarked divergence between observation and theory demands explanation, since Mr. Barnard on October 29 found an even greater breadth of the dark band of 0.65 sec."

"From the very interesting notices of Mr. Barnard on the appearance of the ring when it became visible on October 29, 1891 (October 30, 1891? see above), the following points deserve prominence. The ring could first be seen at a distance of about 2 sec. from the edge of the disk; also the two halves on either side were not the same; and lastly Mr. Barnard perceived two bright knots on the western one. The first fact can, if one pleases, be explained by the proximity of Saturn's bright disk; but another circumstance comes in here, as will be shown. The second fact demands no further discussion; while for the explanation of the third Mr. Barnard assumes that he saw two of the inner satellites. But Mimas only could be in question; and it might raise difficulties to explain both knots by it. So the explanation needs no extended discussion, as it appears to me very probable that here another phenomenon is exhibited."

Seeliger then goes on to attribute it to greater showing in the line of sight; and he deduces from the known dimensions of the ring-system the places where such ansal broadening would cause apparent maxima, to wit:

at 1.60 } radii of Saturn from the planet's center.
and 1.98 }

We may here remark parenthetically that apparent agglomerations or thickenings of the rings have been noticed by several observers since the time of Herschel, by Bond, Wray, and Struve in especial, and agreeing more nearly than the above with the phenomena observed at Flagstaff; but all the observers attributed them to causes other than what we shall now set forth.

Taking up first the shadow phenomena seen at Flagstaff, calculation shows that the shadow of the whole ring-system, including the crape ring, with the sun as on November 9 (1907) 1 deg. 39.5 min. above the ring-plane, would be 0.26 sec. wide only. The position of the earth does not sensibly change this. Now the shadow was nearly twice as wide as this, being 0.46 sec. Such then cannot be the cause. Nor can it be the penumbra of the dark core, as that would be but 0.05 sec. in width, a quantity indistinguishable in fact by the eye. The only explanation left is that in the black core we are looking at the shadow of ring A practically plane and in the dusky shadow about it through particles situated above and below that plane lying in the other rings. In other words, that ring B and ring C are for the most part not flat rings but tores.

Turning now to the phenomena of the rings themselves, the agglomerations on the Olbers-Seeliger theory of their showing should, as computed in the same memoir by Seeliger, be found at

1.60 and 1.98 radii of Saturn from the planet's center; for these are the points where the line of sight from the earth traverses the greatest ansal breadth of the rings at their densest.

Instead, however, of being so found, the present thickenings occur in striking contrast to this, the maxima showing where the minima should and the minima where the maxima would be; since their centers are situate at 1.27 and 1.83 with a conspicuous gap at 1.60 and another falling-off at 1.92 outward. It is not, then, to line of sight massing from particles in one plane that the observed effect is due.

But the moment we let our thought wander out of

* From the Philosophical Magazine for April, 1908.

* Mr. Oudemans here refers to the whole shadow, as appears from Barnard's measures of it cited below. Neither he nor Barnard saw its black core.

the plane we light upon an explanation which satisfies the phenomena. For suppose portions of the rings to be not flat rings but tores, that is, rings after the manner of anchor-rings, encircling the planet. Then, viewed edgewise, such a tore would make its presence perceptible by humps of light in two patches symmetrically placed on either side the planet; to wit, at its ansæ where the sight-line would penetrate the greatest amount of it. The agglomerations, then, can represent tores, but cannot represent flag rings.*

Thus we are led by the phenomena presented by the rings to the same explanation to which those of the shadow conducted us. Furthermore, it is to be remarked that the line of argument in each case is independent of the other. For in the one case, in the shadow, we are reasoning on what we note from a transverse viewing of the tores; in the other, the rings themselves, from a longitudinal aspect of them in the bright agglomerations. As the two deductions lead to the same result, each gains corroboration from the other.

So much for the facts. They conduct us to a conclusion of interest from the point of view of celestial mechanics. To see this we will briefly recapitulate what has previously been shown of the stability of the rings. Laplace first showed that the rings could not be, as they appear, wide solid rings, inasmuch as the strains due to the differing attraction of Saturn for the several parts must disrupt them. Pierce then proved that even a series of very narrow solid rings could not subsist, and that the rings must be fluid. Finally, Clerk-Maxwell demonstrated that even this was not enough, and that the rings to be stable must be made up of discrete particles, a swarm of meteorites, in fact. But, if my memory serves me right, Clerk-Maxwell himself pointed out that even such a system could not eternally endure, but was bound eventually to be forced both out and in, a part falling upon the surface of the planet, a part going to form a satellite farther away.

Even before Clerk-Maxwell's time, Edward Roche in 1848 had shown that the rings must be composed of discrete particles—mere dust and ashes. He drew this conclusion from his investigations on the minimum distance at which a fluid satellite could revolve around its primary without being disrupted by tidal strains.

The dissolution which Clerk-Maxwell foresaw can easily be proved to be inevitable if the particles composing the swarm are not at considerable distances from one another; and that they are not at such distances apart is certainly the case with rings A and B, as is witnessed by the light those rings send us, even allowing for the comminuted form of their constituents. Now a swarm of particles thus revolving round a primary are in stable equilibrium *only in the absence of collisions*. But in a crowded company collisions, due either to the mutual pulls of the particles or to the perturbations of the satellites, must occur. At each collision, although the moment of momentum of the two particles remains the same, energy is lost unless the bodies be perfectly elastic, a condition not found in nature, the lost energy being converted into heat. In consequence, some particles will be forced in toward the planet while others are driven out; the greater number falling in until at last they are brought down upon the body of the planet.

Now the interest of the observations at Flagstaff consists in their showing us this disintegration of the rings in process of taking place, and furthermore in a way that brings before us an interesting case of celestial mechanics.

In considering the action of one body upon another revolving around a third, the points germane to our present inquiry are the perturbations in the radius vector and in the longitude of the second body.

Now, by the method of variation of parameters the radius vector of the perturbed body—the disturbed particle in the present case—may be expressed, as has been done by Airy, by

$$r_1 = \frac{a_1(1-e_1^2)}{1+e_1\cos(\theta_1-\omega_1)}$$

where the subscripts refer to the variable elements. The perturbed longitude may similarly be expressed by

$$\theta_1 = n_1 t + e_1 + \left(2e_1 - \frac{e_1^3}{4} + \text{etc.}\right)\sin(n_1 t + e_1 - \omega_1) + \text{etc.}$$

These may be expanded in an ascending series of terms according to powers of the eccentricities and of cosines of multiple arc of the mean motions of perturber and perturbed by Fourier's series. The resulting expression is composed of terms similar to those in the undisturbed orbit, and of others denoting the effect of the perturbation. The latter are of the typical form:

$$\frac{P e^{q} e'^{q'}}{pn - qn'}\cos\overline{(pn-qn')t - Q}$$

where P is a function of a and a', the radii vectores of the perturber and perturbed, and of μ the mass of Saturn and the perturbed body.

The form of these terms shows that they will become considerable in proportion as $pn - qn'$ is small, since their coefficients are divided by this quantity. Now as n and n' are the mean motions of perturber and perturbed, if these are commensurate there will always be terms of the sort which will be large, namely, those in which $\frac{q}{p} = \frac{n'}{n}$; for p and q are always integers, in consequence of the method of expansion.

The various terms with the argument $(pn - qn')t$ will have coefficients of different powers of the eccentricities. The lowest of these which can occur in the expressions will be of the order $p - q$. The term, therefore, in which $x + x_1 = p - q$ is the term least diminished by the eccentricity coefficient, and therefore the most potent in its effect.

From this it is evident that two bodies will mutually disturb each other in their revolutions about a third according as their periods are:—

First. Commensurate.

Second. Differ by the smallest integer.

The most disturbing ratio is when the periods are:

1 : 2; 2 : 3, etc.;
the next, 1 : 3; 3 : 5, etc.;
then, 1 : 4; 2 : 5, etc.;
and so on.

The initial ratio in each line will be the most effective in that line, because the cycle of the disturbance will be repeated in the time it takes the outer body to come again into conjunction with the inner, and for this the ratio 3:5, for instance, will be three time as long as that of 1 : 3.

The same thing can be seen geometrically by considering that the two bodies have their greatest perturbing effect on one another when in conjunction, and that if the periods of the two be commensurate, they will come to conjunction over and over again in the same points of the orbit, and thus the disturbance produced by one on the other be cumulative. If the periods are not commensurate the conjunctions will take place in ever shifting positions, and a certain compensation be effected in the outstanding results. In proportion as the ratio of periods is simple will the perturbations be potent. Thus with the ratio of 1 : 2 the two bodies will approach closest only at one spot, and always there, until the perturbations thus induced themselves destroy the commensurability of period. With 1 : 3 they will approach at two different spots recurrently; with 1 : 4 at three, and so on. The number of points round the orbit at which they will meet is in fact as the sum of the powers of the eccentricities in the lowest coefficient of the terms with the commensurable argument.

We see, then, that perturbations, which in this case will result in collisions, must be greatest on the particles having periods commensurate with those of the satellites. But inasmuch as there are many particles in any cross-section of the ring, there must be a component of motion in any collision tending to throw the colliding particles out of the plane of the ring, either above or below it. Such extra-plane particles would, therefore, be most numerous just inside the points of commensurability, because, though the moment of momentum is preserved and thus particles be thrown outward from the points as well as in, owing to the loss of energy they must be more numerous on the inside.

Considering, now, the commensurate ratios between the periods of particles and satellite which can enter into the problem, we find these in the order of their potency to be:

With Mimas, 1 : 2,
1 : 3,
1 : 4,
With Enceladus, 1 : 3,
With Tethys, 1 : 4.

Such periods of commensurability as 2 : 3 of Mimas and 1 : 2, 2 : 3 of Enceladus do not come into question as they take place outside the ring-system. Now calculation shows that the distances corresponding to a period of 1 : 2 of Mimas, of 1 : 3 of Enceladus, and of 1 : 4 of Tethys fall in Cassini's division, which separates ring A from ring B. The first or outer tore should therefore occur just outside that division or in the outer part of ring B. This is precisely where we find it; for the inner edge of Cassini's division is at 1.92 radii of Saturn from the center of the planet, and the outer tore begins at 1.92, thence to stretch inward toward the disk. Pursuing our inquiry with the next most effective ratio, that of 1 : 3 of Mimas's period, we note that its corresponding distance falls at the boundary of ring B and ring C at 1.495 radii of Saturn from the center. Now it is inside this, to wit, at 1.46 and 1.42, that the inner tore begins. Furthermore, this tore is much longer than the outer one. We turn, therefore, to the next most potent ratio, that of 1 : 4 of Mimas's period, to find that its distance falls at 1.24. This then accounts for the greater length of the inner tore.

The remarkable way in which theory thus accounts for observation is of interest, and the more so from involving a case of celestial mechanics interesting in itself.

EFFECTS OF LIGHT.

IT is found that when a photographic plate has received the effect of light rays or X-rays, this effect can be destroyed by exposing the plate to rays which have another character. This fact is brought out in the recent researches of Gargam de Moncetz, of Paris. Prof. Becquerel noticed that the infra-red rays which lie nearest to the visible red will destroy the impression which is produced on a plate by rays of smaller wave lengths, which are used in ordinary photography. M. Villard obtained the same result by replacing the luminous rays by the X-rays. The destructive effect, which extends from λ 800 to λ 1,000, or nearly, has been utilized for photographing this infra-red region. The author takes up the researches with the X-rays, and varies the time of exposure in a regular manner. Having at first used a spectrograph with a flint prism, he found that just after the destructive rays there exists another group of rays which are less refrangible and have the effect, no longer of destroying the impression produced on the plate by the X-rays, but on the contrary, of acting in some measure as "continuing" rays. To make the experiment more conclusive he replaces the flint prism by two fluor-spar prisms and to remove the idea of a fog on the plate by the different light he places before the spectrograph slit a cell containing a solution of iodine in carbon disulphide. This shuts off all light which would act on the plate in the normal state, and transmits the rays whose wave-length lies between λ = 800 and 4 μ. Under these conditions with a Nernst lamp of 32 candle power and a Lumiere plate which is first fogged by the X-rays, there is naturally an absence of impression of the spectrum before λ 800 and then we find a destruction of the original fog between λ 800 and λ 920. But beyond that, the plate shows a distinct increase of the fog, which extends from λ 920 to λ 1,350. The same experiment was carried out with plates which were fogged, not by X-rays, but by ordinary light (red light, for instance) or with non-fogged plates. Here there is no trace of this extension, even with long exposures. The present phenomenon seems thus to be limited to photographic films, which have received the action of the X-rays. It is to be remarked that there is not a complete analogy between this newly-observed action and the "continuating" effect observed by E. Becquerel and Villard, which requires the use of a photographic preparation containing salts soluble in water. Prof. Becquerel recognized that the presence of these soluble salts was quite essential in order to have the continuing effect of the yellow and green rays, and M. Villard, who lately recommended these experiments, did not obtain any continuation with bromide of silver plates. The author proposes to continue these researches.

Some interesting figures are given in a printed reply to Mr. Molteno by the President of the Board of Trade with regard to the shipping through the Suez Canal. The total net tonnage of vessels of all nationalities passing through the canal was as follows: 1905, 13,134,105 tons; 1906, 13,445,504 tons; 1907, 14,728,434 tons. The net tonnage of British vessels passing through the Canal during those years was as follows: 1905, 8,356,940 tons; 1906, 8,299,931 tons; 1907, 9,495,868 tons. The total receipts from transit dues were as follows: 1905, 113,866,796 francs; 1906, 108,161,896 francs; 1907, 116,000,096 francs. Mr. Churchill states that no account of the receipts from transit dues on British ships is published, but it is probable that the proportion of these receipts to the total receipts is similar to the percentage of British net tonnage to the total net tonnage.

* NOTE.—It seems necessary to suppose that we see through the ring to its partially illuminated side; for from observations made or published since this article was written, it appears that the agglomerations disappear when either the sun or the earth passes through the plane of the rings.

Thus Mr. Lampland's observations of the rings gave:

December 31. Agglomerations visible.
January 1. Ansæ too faint to detect structure.
January 3 and 4. Ansæ continuous.
January 7. No agglomerations. Rings easily seen.

Earlier observations by Aitken at the Lick, July 23 to October 12, show that no agglomerations were seen between those dates. See Barnard to the same effect.

Since this was written Barnard has published his observations with his explanations. His explanations, however—for he gives two—one that the eye sees through the underside of the rings and that such light is greatest where the rings are densest, the other the exact opposite, that the light is most where the ring is least crowded—are self-condemning on several counts; one, for instance, that the inner condensation does not fall by his own showing on the ansal position of any part of ring A but wholly on the crape ring. Each explanation might possibly account for one agglomeration alone, but for that very reason fails for both together. The presence of the gaps is another fatal objection to them.

As seen at Flagstaff, under the same seeing that disclosed the dark core to the rings' dusky shadow, the agglomerations were fairly continuous, though uneven, for the whole length of them measured on November 9. Their vertical width was about 0.20 sec., while that of the continuous ring was about 0.02 sec., giving for the width of the main plane of the rings some 80 miles or 130 kilometers.—P. L.

SCIENCE NOTES.

One of the latest developments arising from the struggle between gas and electric light for supremacy has been the devising of the high-pressure system for the former illuminant, which in conjunction with the incandescent mantle yields an exceedingly powerful light at a low cost. In Germany this latest improvement has been carried to a furtner degree. In this case the gas is compressed for the supply to the burner by means of a simple machine driven by the waste heat of the lamp transformed into electric energy. The result of this device is that each lamp is complete with its own compressing apparatus instead of being dependent upon some central compressing station, as is the case with the present high-pressure system. The light derived from this new invention is claimed to be very powerful, while it is said to be very economical in gas consumption, and occupies but little space. The main objection to any such system, however, would appear to be in connection with the compressing device, but this is stated to be so simple and has proved so reliable after a prc'onged test that no apprehensions need be entertained regarding its reliability and working.

At the General Conference on Weights and Measures, held at Paris in October last, a resolution was unanimously passed urging the universal adoption of a metric carat of 200 milligrammes as the standard of weight for diamonds and precious stones. This proposal, which received a large measure of support on the Continent, especially in France, Germany, Spain, and Belgium, was brought under the notice of the principal diamond dealers in England by the Board of Trade early in the present year, but it has not met with a favorable reception from the trade, and unless the proposed new standard is generally adopted abroad it is unlikely that any further action in the matter will be taken by the government. The French ministry is now introducing a bill to legalize the "metric carat" of 200 milligrammes in that country, and to prohibit the use of the word carat to designate any other weight. A recent resolution of the Bombay Chamber of Commerce shows that the proposal for an international standard carat is receiving favorable consideration in India.—Nature.

In a short paper on "The Influence of Sunlight on Paints and Varnishes," recently communicated by Mr. Maximilian Toch to the New York section of the Society of Chemical Industry, some interesting comments on bituminous paints were made. The author expressed the opinion that "the painting of concrete to preserve it against the action of moisture and frost is destined to become as large an industry as the painting of wood," but said that those who have used asphalt paints for concrete have found that disintegration of the asphalt occurs in a very short time. He regards the decomposition of the bitumen as the effect of exposure to the combined action of sunlight, air, and moisture, and states that free carbon is one of the products of decomposition. Linseed-oil paint is rapidly destroyed by concrete, owing to the action of the lime on the oil, but Mr. Toch does not regard the destruction of bitumen painted on concrete as due to any action of the concrete upon it. Although the author speaks so confidently with regard to the future use of paint for preserving concrete, his paper shows only that certain paints are unsuitable for use on concrete exposed to sunlight and air and rain. He leaves us in ignorance as to what paint is, in his opinion, the most suitable for use as a preservative on concrete.

Dr. Glikin has recently published the results of his investigation of the proportion of iron in the marrow of the bones of various domestic animals and of man, and has come to the conclusion that the younger the animal, the greater the proportion of iron. Thus, in the case of a new-born pig, the amount of iron in the marrow was 1.15 per cent, while the amount was only 0.30 per cent in a pig six weeks old, 0.15 per cent in one of eight weeks, and was no more than 0.03 per cent in full-grown animals. Similarly, a new-born puppy yielded 4.35 per cent of iron, a dog of five weeks, 0.44 per cent, a dog of ten weeks, 0.32 per cent, and a full-grown animal 0.05 per cent. An analogous decrease in the proportion of iron also occurs in the liver. For instance, in the case of rabbits, the proportion of iron in the cells of the liver falls from about 10 per cent to about 0.4 per cent during the first three months after birth, while the liver of a new-born calf contains about seven times as much iron as that of a cow. There is some doubt as to the form in which the iron is present in the marrow, but it appears to be in combination with the complex organic phosphorus compound known as lecithin, which is one of the most important constituents of the substance of the brain and of the yolk of egg. The ratio of iron to phosphorus in the marrows agreed closely in many cases with that required for a compound containing one atom of iron combined with three molecules of lecithin, and the proportion of iron was found to decrease in almost the same proportion as did the lecithin during the growth of the animal.

ENGINEERING NOTES.

The slide rule was invented by Gunter shortly after his discovery of logarithms in 1620 according to an article in the Zeitschrift fuer Vermessungswesen, by Karl Luedemann. Gunter placed logarithmic scales on wooden rules and used a pair of dividers to add or subtract the logarithms. In 1627 the logarithmic scales were drawn by Wingate on two separate lines sliding against each other, so as to render the use of dividers unnecessary, and in 1657 Partridge brought out the slide rule in its present form. The circular form was devised by Leblond in 1795.

From the returns compiled by Lloyd's Register of Shipping, it appears that, excluding warships, there were 386 vessels of 799,178 tons gross under construction in the United Kingdom at the close of the quarter ended June 30, 1908. The tonnage now under construction is 48,000 tons less than that which was in hand at the end of last quarter, and 451,000 tons less than that being built twelve months ago, and is the lowest total recorded in the society's returns since 1896. There were also under construction at royal dockyards 12 warships of 112,820 tons displacement, and at private yards 37 of 86,672 tons for the British government, and 17 of 51,060 tons for foreign governments, making a total of 54 warships of 137,732 tons.

The monopoly of casting houses is not to be allowed to Mr. Edison. Other inventors maintain they have already succeeded in excelling him. Mr. Hatt, an Englishman, who is known from his color-printing presses, has applied for protection for a system by which a house can be produced in four days. The first day is occupied with arranging the steel-plate molds and preparing the concrete, and at night the lowest storey is cast. A storey per day is the estimated rate of progress, and on the fourth day the roof is completed along with the upper part of a four-storey habitation. Not only the shell, but chimneys, stairs, fireplaces are comprised in the operations. Ornament is also obtainable to any extent by introducing a special mold within the mold for walls. The cost of the apparatus is said to be much less than with the Edisonian system. The experience of occupiers of cast houses would be desirable before companies are formed to carry out buildings in which builders have no part.

By the completion of the dam across the Cataract River, 50 miles from Sydney, a notable engineering work has been added to other evidences of enterprise in Australia. The length of the dam is 811 feet at the crest, and it rises to the height of 157 feet above the river bed, below which the foundations extend to the maximum depth of 35 feet. The thickness of the masonry is 158 feet at the base and 16 feet 6 inches at the top. The hearting of the dam is of cyclopean rubble masonry, consisting of sandstone blocks, weighing from 2 tons to 4½ tons, imbedded in concrete. Outside the masonry are layers of concrete 3 feet thick, and then come facing blocks of concrete. This order of the materials is the reverse of that generally adopted, the reason in the present case being the liability of the local sandstone to deteriorate under atmospheric influences. To show the importance of the structure we may mention that it has provided a reservoir with the storage capacity of more than 21,000 million gallons, a very welcome addition to the modest reserves previously available for the water supply of Sydney. The dam has been described and illustrated in the columns of the SCIENTIFIC AMERICAN SUPPLEMENT.

Mr. E. W. C. Kearney recently gave a demonstration of his high-speed railway system in the temporary building on the east side of Aldwych. Mr. Kearney runs his car upon a single rail, supporting it upon a two-wheel bogey at each end. Above the car is a second rail engaging a second two-wheel bogey at each end. The upper and lower bogeys are carried upon the same shaft, and so turn together. The intention is to run out of the ground-level stations down an incline of 1 in 7 until a speed possibly of 200 miles per hour is attained, then along the level, and so up to the next stat .. If this could be done safely and successfully, then, without question, much time would be saved; but nothing which was said or demonstrated at that time with the help of a scale model about one-fifteenth the full size in any way made it evident that this would be the case, or that the great economy in first and in running cost claimed would be attained in practice. While the steep declivity would be convenient in the case of tube railways, it hardly meets the requirements of elevated or of long-distance railways, for which the motors would have to provide the whole acceleration. Might it not be well to revive the old brachistochrone problem which the brothers Bernoulli invented before its time and travel on cycloidal routes from place to place? Even Mr. Kearney would find it difficult to compete with this.—Nature.

TRADE NOTES AND FORMULÆ.

To Fix Chalk Drawings.—Dissolve 40 parts of al and 20 parts of isinglass in 2,000 parts of rain wat by boiling; strain the mixture through linen and ad to it about 250 parts of alcohol. The paper may b dipped in the liquid, or the latter can be poured over i

Artificial wool is a mixture of vegetable fibrous su stances (jute, hemp, nettle, flax, etc.) with wool. Th first to be boiled with caustic lye at 221 deg. F. fo half an hour and washed; then, during repeated boi ing in a second vessel, to 100 parts of goods 0.062 par of blue vitriol ammonia and 2 parts of soda are added the goods washed out, dried, and mixed with the wool

Air-Tight Cork Stoppers.—Steep corks for sever hours in a solution of 15 parts of gelatine or goo glue and 24 parts of glycerine in 500 parts of wate at a temperature of 111 deg. to 118 deg. F., and then dry them. They may be made impervious to acids and other chemicals by steeping in a mixture of 2 parts o vaseline and 7 parts of paraffine, heated to 104 deg. F

Chemically Pure Copper.—Dissolve 1 part of blu vitriol in 10 parts of water, to which a few drops o hydrochloric acid have been added, immerse in th fluid a pice of stout sheet zinc and move it about until the fluid is completely colorless. The copper is separated on the zinc in the form of a delicate mass brown powder (cement copper) which is filtered off washed in distilled water, dried and preserved in closely sealed receptacles.

The Production of Rubber Stamps by Means of Glue.—On the set type several sheets of tinfoil are placed and in connection with a felt, subjected to a single pressure in a hand press. The tinfoil matrix is then removed from the type and lightly oiled. Around the matrix oiled lead rims are placed, after which pure joiners' glue, to which a little roller composition has been added, is poured over the matrix. After cooling the mass is easily removed.

Cork Stones.—Cork waste (from cork factories, old bottle corks) is ground to fragments as large as a pea and this mixed in a vessel fitted with stirring apparatus, with powdered asphalt. The vessel is then heated by external steam until the asphalt melts and the whole mass is transformed into a sticky paste which is pressed hot into iron molds and allowed to cool. Another, less solid, form of cork stone or brick is obtained by stirring the cork fragments into thick lime-milk, forming the mass into tiles and exposing them for several weeks to atmospheric action. Cork stones are particularly adapted for the erection of high buildings and for the insulation of apartments that must be protected from external heat and cold, like refrigerator and fermenting rooms, steam chambers, etc.

Rubber Stamps.—A vulcanizing apparatus, with thermometer and lamp, also an iron printing frame (chase) in which all the letters can be tightly locked, are required for the manufacture of rubber stamps. The printing frame must be of such form and size that the matrix taken from it will fit into the vulcanizing apparatus. These matrices are obtained when, as in the ordinary stereotyping process, the type is oiled and the mass spread over it. When the plate is formed it must be carefully taken off without being allowed to dry, and on the stereotype form is placed a piece of vulcanizing rubber, impregnated with sulphur and soap stone. Then the superimposed stereotype and rubber plates are placed between two iron plates that are drawn together by screws and the rubber by this means is pressed into the stereotype mold. To prevent the rubber sticking to the iron plate, a few sheets of paper are placed between them. When the plates are screwed sufficiently tight together, the rubber, with the stereotype form, is placed in the water of the vulcanizing apparatus, the lid screwed down and the temperature raised to 305 deg. F.; allow it to cool, take the mold with the rubber out and carefully detach the rubber. It does not come off easily when the mold has been placed wet in the apparatus. The caoutchouc plate is then cut up so as to separate the different names; these are then glued on the handles and the stamps are finished.

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